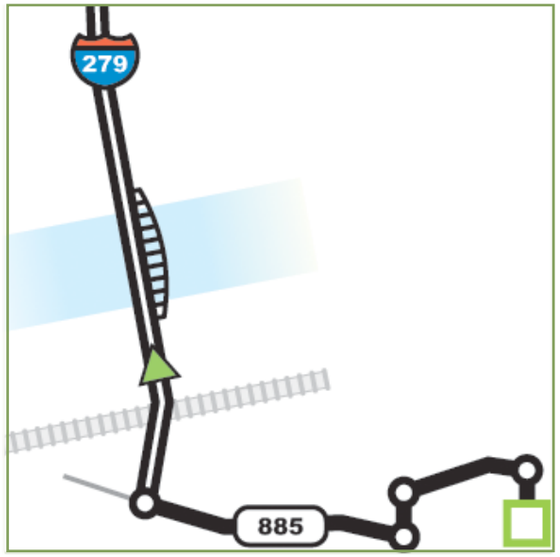
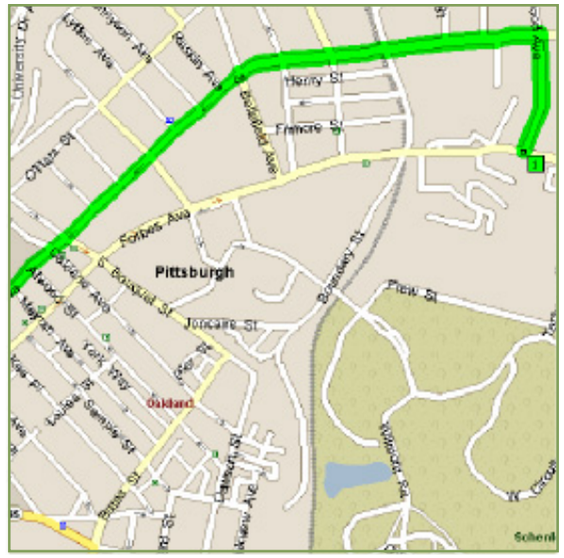
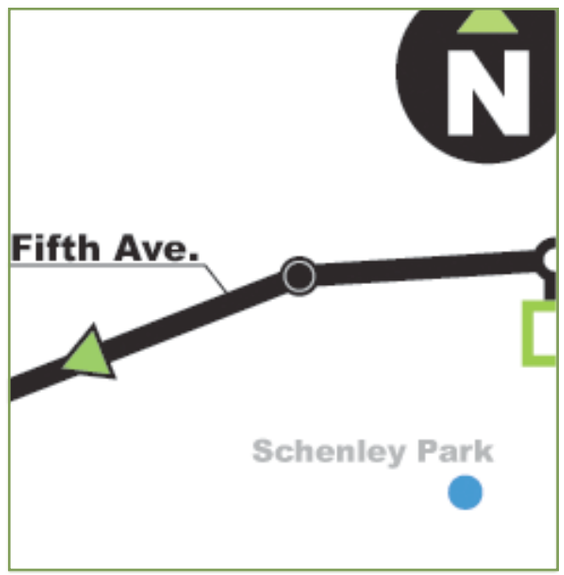






Proposal

Designing Perceptually Optimized Displays

Joonhwan Lee

Human-Computer Interaction Institute
Carnegie Mellon University

Motivation

- Information is useful, but we often surrounded by information overload.
- If an user is engaged with attention demanding task, then supplementary information is more or less distracting, sometimes dangerous even though it is useful.
- The value of information remains important and useful when it is delivered in appropriate way.
- Perceptually optimized information display that considers user's certain situation might be a solution to this concern.

Motivation

- Driving context is a good example of this concern:
  - driving requires a lot of attention.
  - navigational information can enhance driver's navigation performance but at the same time, it could seriously interrupt driving task.
- However, current navigational information display does not consider driver's cognitive load and attentional state.

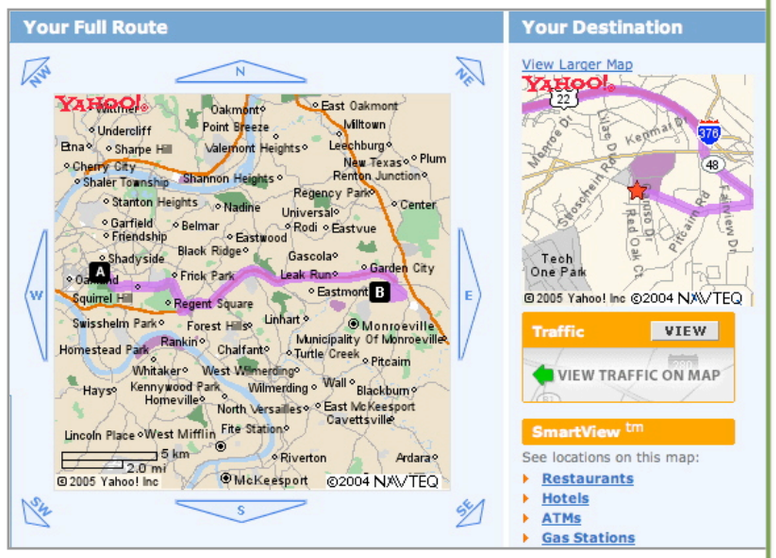
In-Vehicle Navigation

- Shift from devising a route out of printed map, various forms of computer generated routes are used in vehicles.
  - e.g., Yahoo Maps, Map Quest, PDA, Laptop, GPS Navigators...
- Each form has tradeoffs.

Tradeoffs of In-Vehicle Navigation

- **Paper Maps**
  (including computer generated maps)

  \+ Can see the overall route
  \- Complex visualization



Tradeoffs of In-Vehicle Navigation

- **Paper Maps**
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  + Can see the overall route
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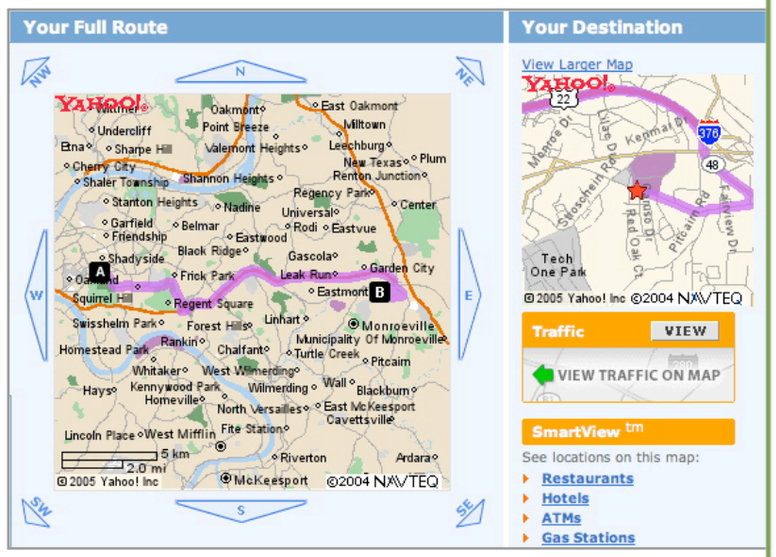
- **Turn by Turn Direction**

  + Simple depiction of entire route
  + Easy to read
  - Usually no visual cues
  - No way to go back to the route when lost



Directions	
1.	Start at **5000 FORBES AVE, PITTSBURGH** - go **2.6** mi
2.	Turn R on **S BRADDOCK AVE** - go **0.9** mi
3.	Turn R on **MONONGAHELA AVE** - go **0.1** mi
4.	Turn R onto **I-376 EAST** toward **MONROEVILLE** - go **7.5** mi
5.	Take exit **#14A/PA-48 SOUTH** onto **ORANGE BELT[PA-48]** toward **MONROE**
6.	Turn R on **DAUGHERTY DR** - go **0.1** mi
7.	Turn R on **NORTHERN PIKE** - go **0.3** mi
8.	**NORTHERN PIKE** becomes **MONROEVILLE RD** - go **0.5** mi
9.	Arrive at **[4034-4099] MONROEVILLE BLVD, PITTSBURGH**

Tradeoffs of In-Vehicle Navigation

- **Paper Maps**
  (including computer generated maps)

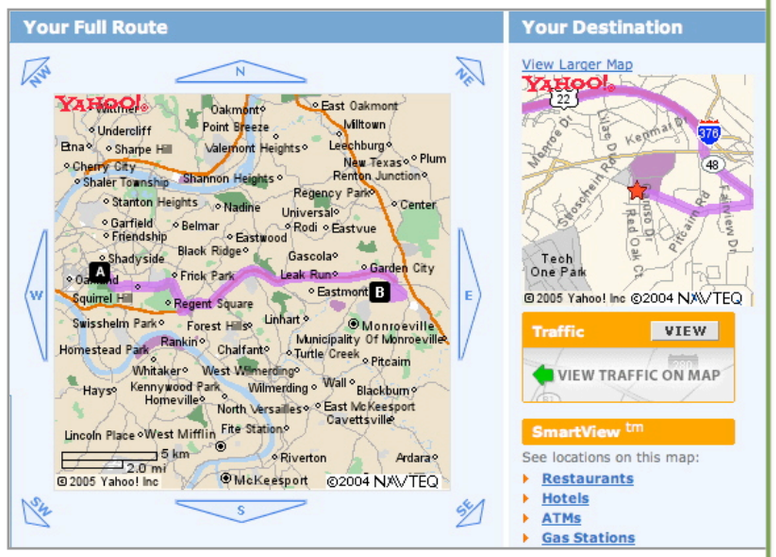
  + Can see the overall route
  - Complex visualization

- **Turn by Turn Direction**

  + Simple depiction of entire route
  + Easy to read
  - Usually no visual cues
  - No way to go back to the route when lost

- **GPS Navigators**

  + Good geographic positioning
  + Dynamic visual cues
  - Cannot see the overall route
  - Provide similar visual complexity as the paper maps provide



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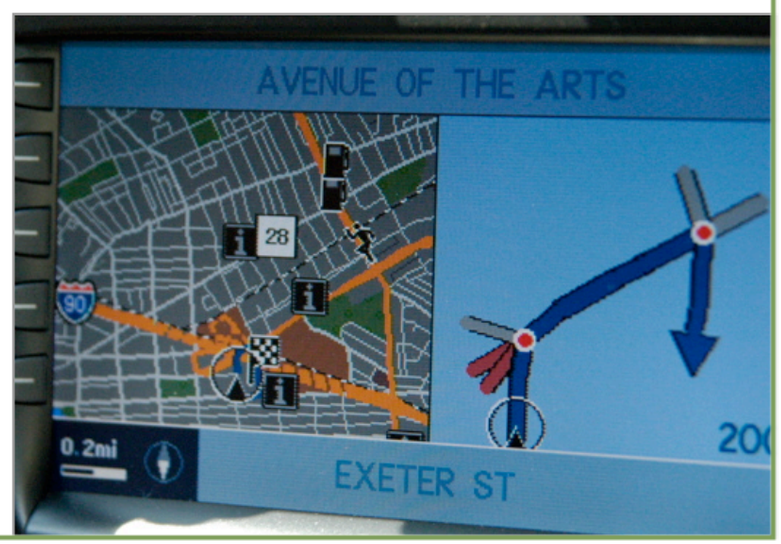


Issues?

- Driving requires concentration.
  - Need to minimize visual distraction caused by other information sources.
- Current maps don't focus on using minimal attention for visual displays
  - simple iconic depiction of a route or
  - removal of visual information (e.g., turn by turn direction).

Mercedes-Benz

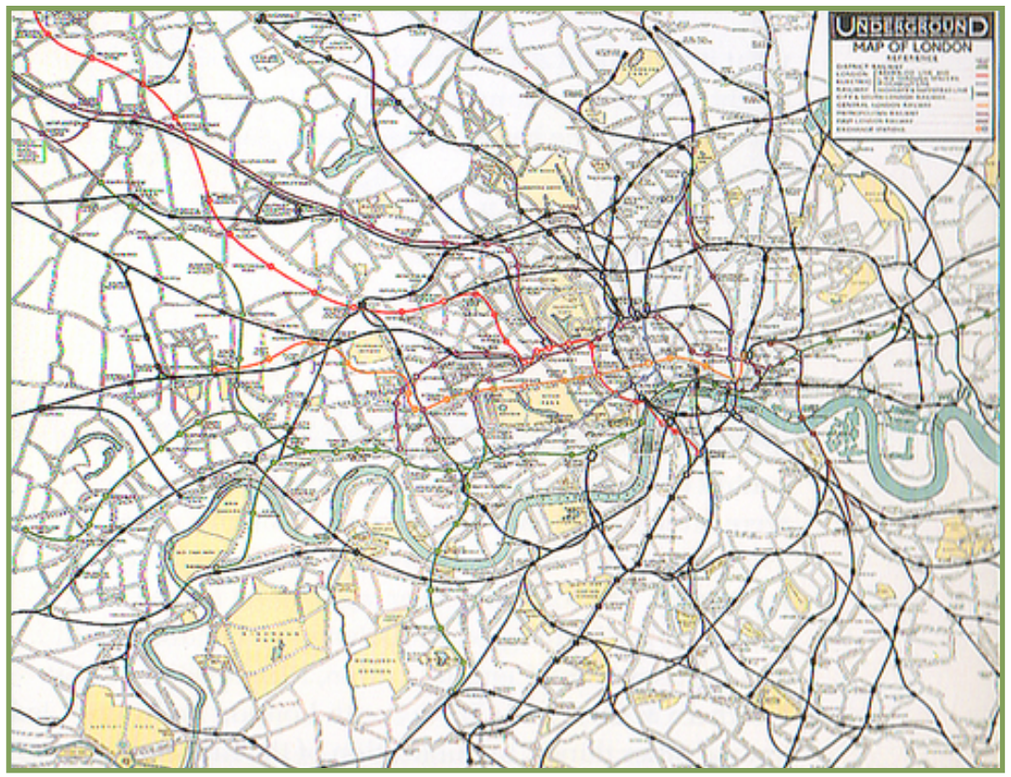
Visualization for Navigation?

- Can dynamic visualization techniques be used to enhance navigation performance while reducing visual attention?

Power of Visualization

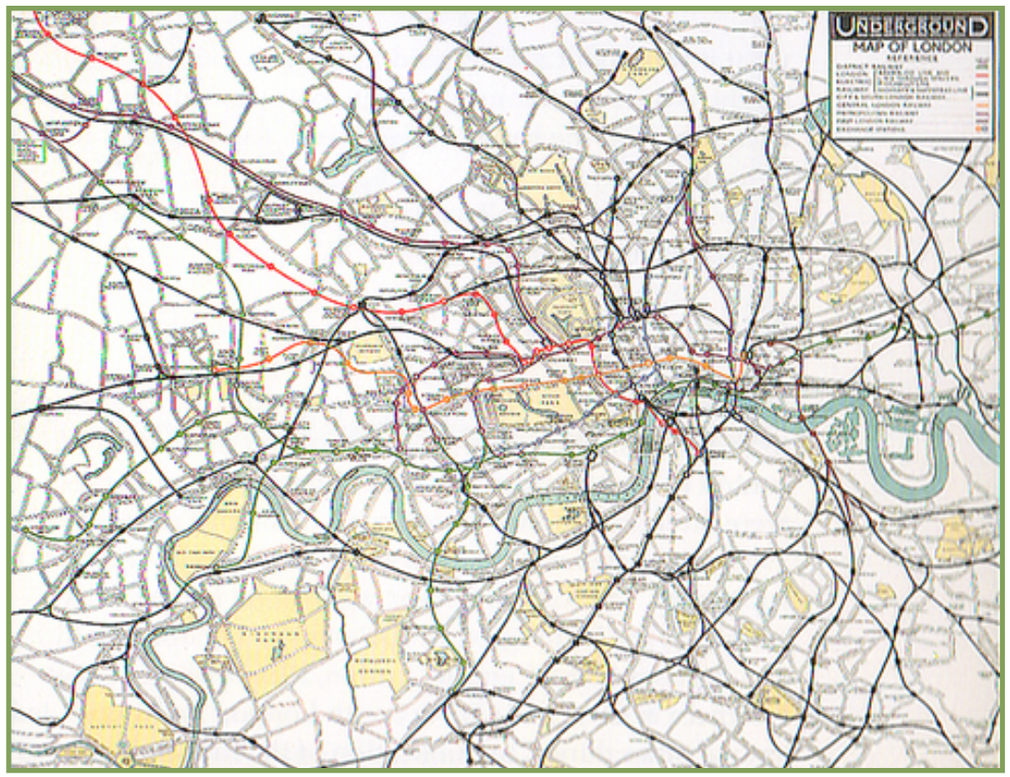
Power of Visualization

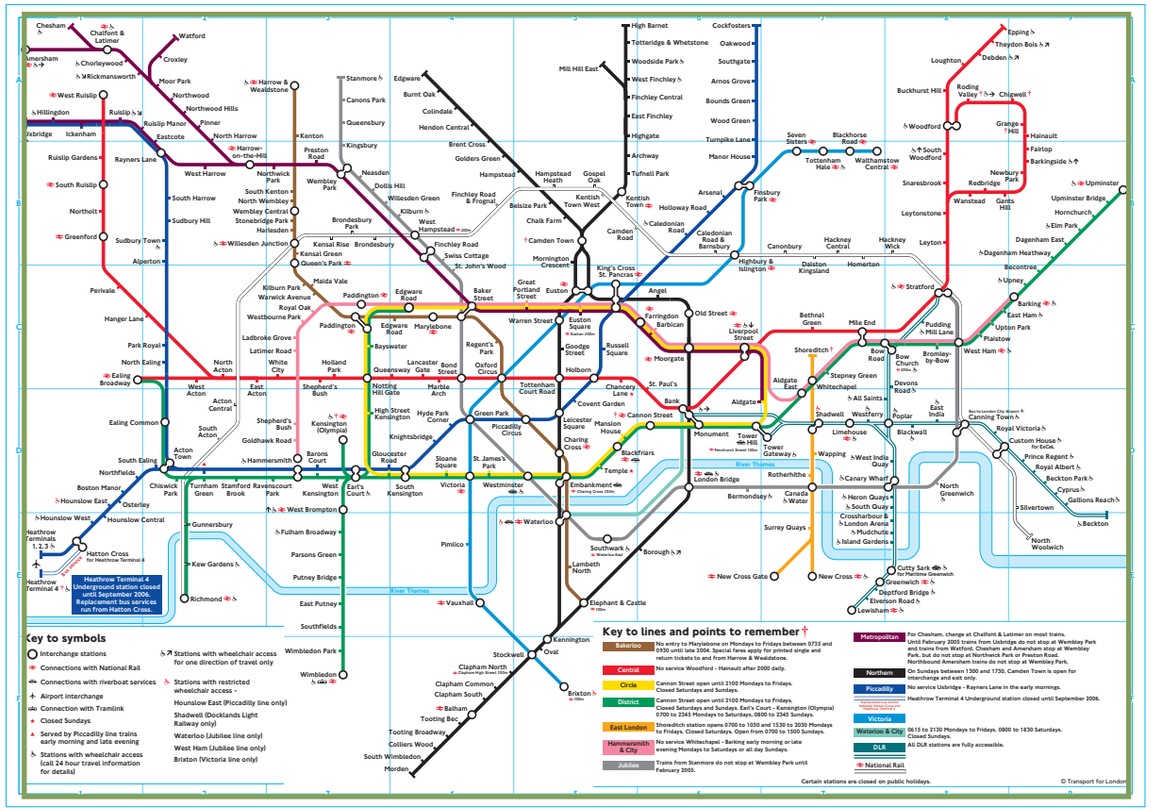
London Underground Map 1920s



Power of Visualization

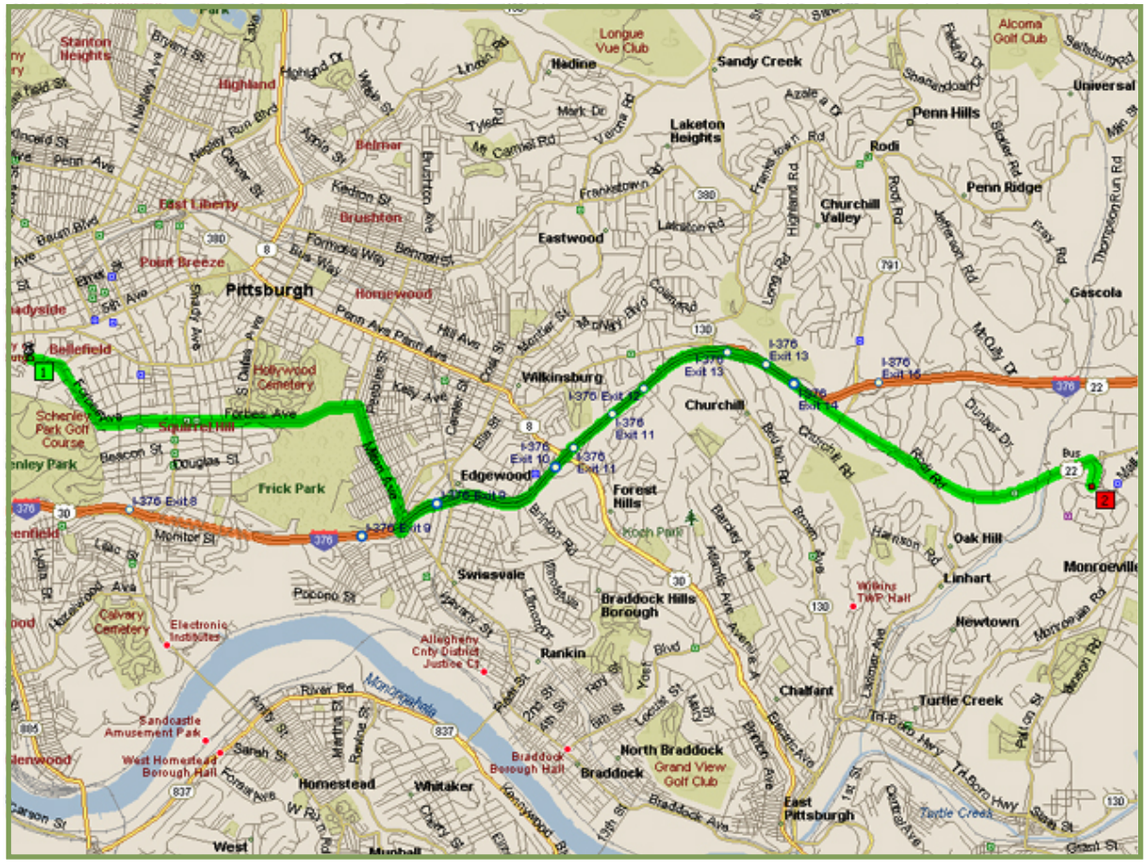
London Underground Map 1920s

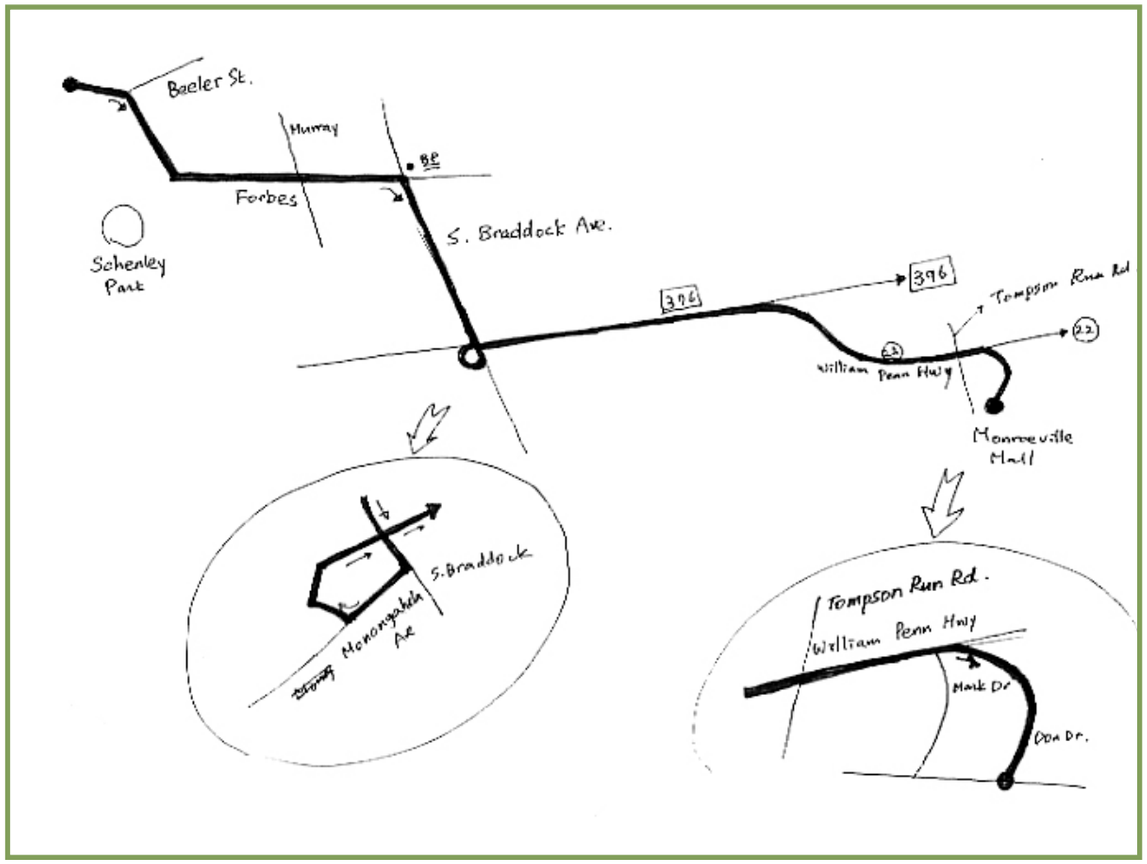




Recent London Underground Map

Map Visualization Example



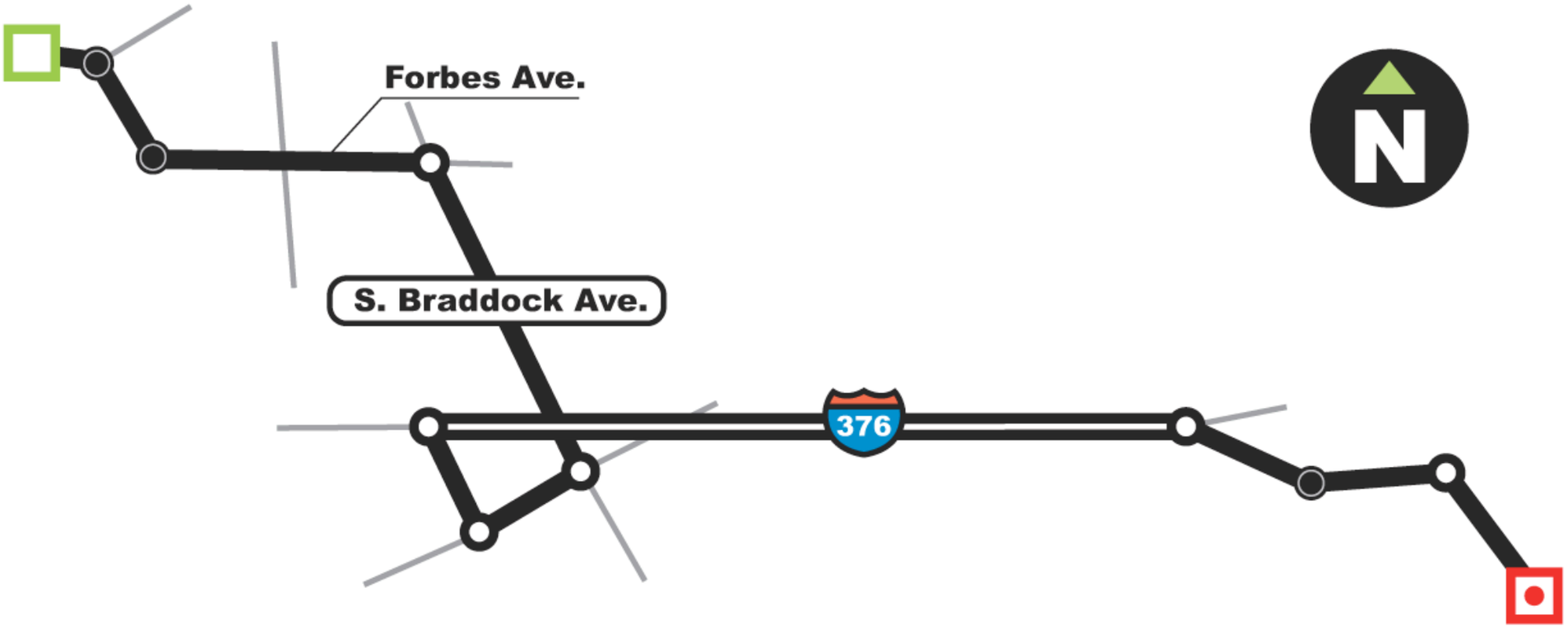


Up | route map, Microsoft Streets and Trips

Down | hand-drawn route map

MOVE Design

- replicated from previous hand-drawn map -



What is MOVE

- **MOVE**: Maps Optimized for Vehicular Environments
- Presents optimized geographic information
  - works on our principle that different information have different importance within a given situation.
  - driver's attention should be expended on the more important information than the less one.
- Navigation interface takes only appropriate amounts of attention
  - abstracted visual information
  - sensitive to driver's context

Overview

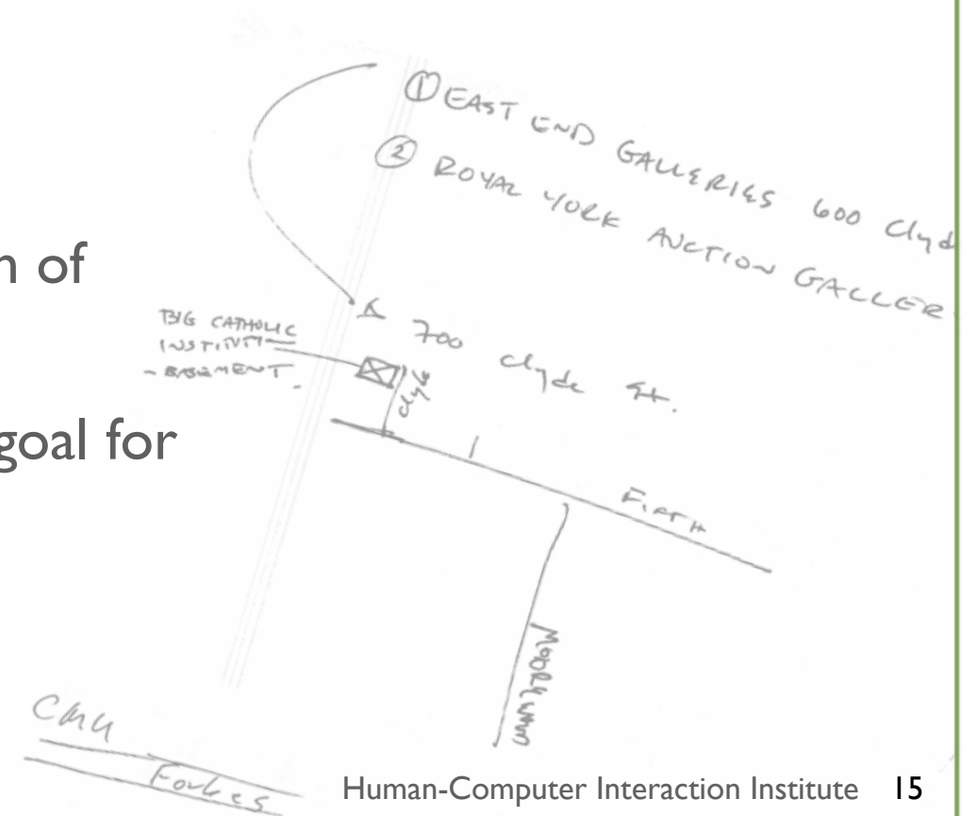
- **Navigation Study and Related Work**
- Visual Search Study
- Design Principles
- Design of MOVE
- Evaluating Prototype Design

Continuing Work

- Implementation of the MOVE System
- Evaluating the Final System
- Contribution and Schedule

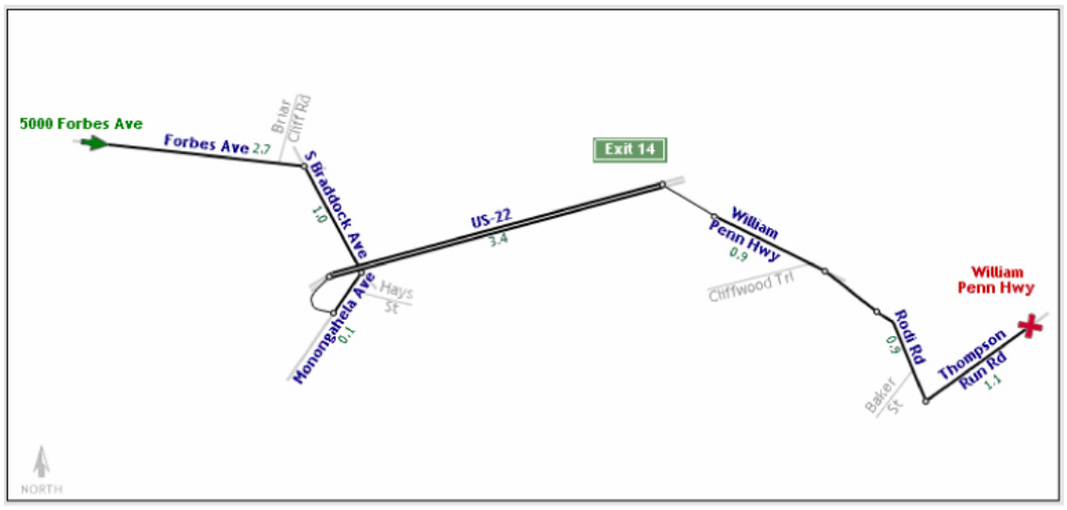
Navigation Study

- Purpose: to get general understanding about navigation practice
- Participants drew a route map with given map and navigated the route
- Findings
  - Landmarks, intersections, paths are primary form of representation
  - Divide route into several chunks and setup sub-goal for navigation
  - Abstracted form was more preferred



Related Research

- LineDrive (Agrawala et al)
  - Successfully used abstraction for static maps accompanied by line-by-line directions.
  - Leverage importance of each segment of a route through optimization.
  - Compared LineDrive with MOVE



	Directions	Elapsed Distance
1	Begin at 5000 Forbes Ave on Forbes Ave and go East for 2.6 miles	2.6
2	Turn right on S Braddock Ave and go South for 0.9 miles	3.6
3	Turn right on Monongahela Ave and go Southwest for 400 feet	3.6
4	Turn right on ramp at sign reading "I-376 E to Monroeville" and go North for 300 feet	3.7
5	Bear right on US-22, I-376, Penn Lincoln Pky and go East for 3.4 miles	7.1
6	Exit US-22, I-376, Penn Lincoln Pky via ramp at sign reading "Exit 14 US-22-BR to Monroeville" and go Southeast for 700 feet	7.2
7	Continue on William Penn Hwy, US-22-BR and go Southeast for 0.8 miles	8.1
8	Turn right and go Southeast for 700 feet	8.2
9	Continue on Rodi Rd, Yellow Belt and go Southeast for 0.8 miles	9.0
10	Turn left on Thompson Run Rd and go Northeast for 1.1 miles to William Penn Hwy	10.1

Related Research

- Cartography and Navigation
  - Monmonier (1996) categorizes the map generalization technique used in cartographic history.
  - MacEachren (1995) explores map visualization in the frame of perception organization and grouping.
  - Several researchers have introduced models for how navigation occurs during a driving task (Michon 1985; Burnett 1988; Ross and Burnett 2001).
    - e.g., trip planning - preview - identify - confirm - trust - orientation (Burnett 1988)

Related Research

- Dynamic information visualization
  - Zoomable UI (Bederson et al)
  - Magic lenses (Bier et al)
  - Fish-eye views (Furnas et al)
  - Detail-in-context visualizations (Mackinlay et al)
  - Dynamic news reader (Ishizaki)

.... saturate detailed information when needed while other contexts are perceptually minimized.

Overview

- Navigation Study and Related Work
- **Visual Search Study**
- Design Principles
- Design of MOVE
- Evaluating Prototype Design

Continuing Work

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- Contribution and Schedule

Visual Search Study

- Designed map renditions to be used in the MOVE display
- Need to know the perceptual effect of the renditions when they are used as target or distracter
  - Target: provide positive communicative benefit
  - Distracter: induce negative effect

Map Reading and Visual Search

- Finding a targeted information in a map is a visual search task
- Two major types of visual search mechanism
  - Bottom-up vs Top-down

Map Reading and Visual Search

- **Top-down**: goal driven and implemented our cognitive strategies
- **Bottom-up**: thought to operate on raw sensory input, rapidly and involuntarily shifting attention to salient visual features of potential importance
- Neither type of mechanism works in isolation in a particular situation; instead, the mechanisms work together interactively.
- Typically bottom-up acts early and the top-down takes over (Conner et al. 2004)

Bottom-up and Pop-out

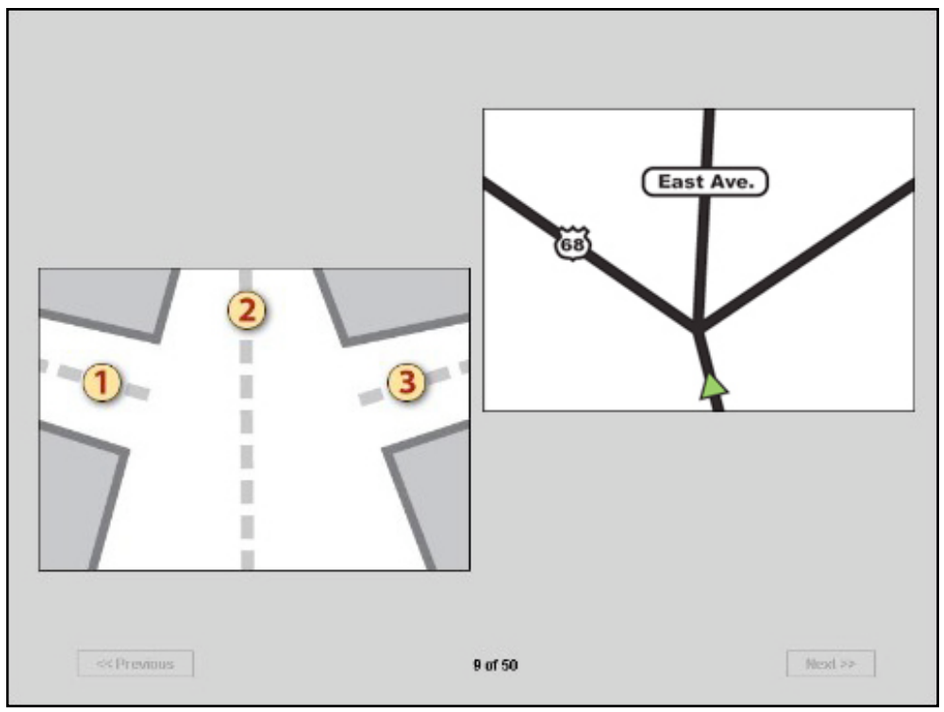
- Pop-out is a bottom-up drawing of attention to an object, which occurs when an object within the visual field is distinctive along some visual dimension (Baldassi & Burr 2004)
  - e.g., possession of a distinctive color or brightness when compared with other objects in the field.

Bottom-up and Pop-out

- Prior studies identified a range of visual features which can induce pop-out effects:
  - color, brightness, movement, direction of illumination, distinct curvature, and tilt (Beck 1982; Julesz 1984; Treisman 1986; Treisman 1998)
- Size has not been shown to strongly induce this effect (Baldassi and Burr 2004)

Visual Search Study:
Overview

- Participants were asked to find target information from a display
- A map stimulus with a road depiction containing several symbols was presented
- Participants were verbally prompted to select a target rendition from a map stimulus, indicating the position of the rendition by pressing a keyboard key

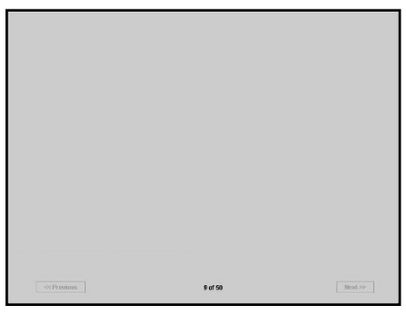


Visual Search Study:
Procedure

- 20 participants from university community participated in the study (12F, 8M, aged 18~33)
- After signing a consent form, participants read instruction of the study to be familiar with the study and the renditions used in the study
- At the end of the instruction, they were presented 5 sample session of the study
- Finally participants completed main study

Visual Search Study:
Procedure

- During the study trials, the participants were presented with a voice prompt using a pre-recorded female voice, indicating which symbol they should select.



- To record reaction time, the experiment software started a timer when the visual stimulus was placed on the screen and stopped when a participant pressed a key.

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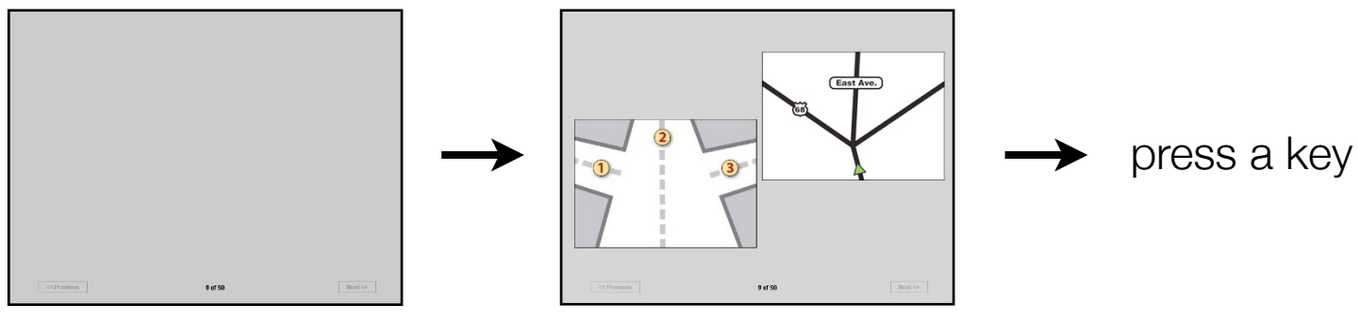


- To record reaction time, the experiment software started a timer when the visual stimulus was placed on the screen and stopped when a participant pressed a key.

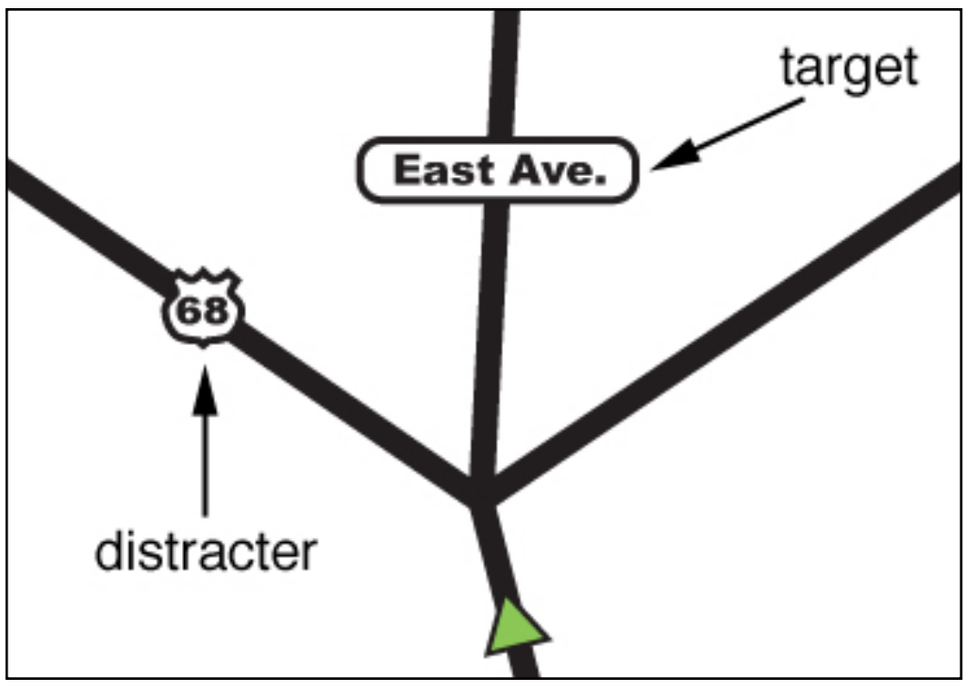
Visual Search Study:
Stimuli

- Stimuli were generated based on 13 renditions chosen from our earlier MOVE design
- 13 renditions: 6 different node renditions, 5 forms of road labels, and 2 other renditions (route start/end)
- In addition, a McDonald's logo was included for highly salient rendition (used for manipulation check)

A	B	C	D	E
				
F	**G**	**H**	**I**	**J**
				
K	**L**	**M**	**N**	
				

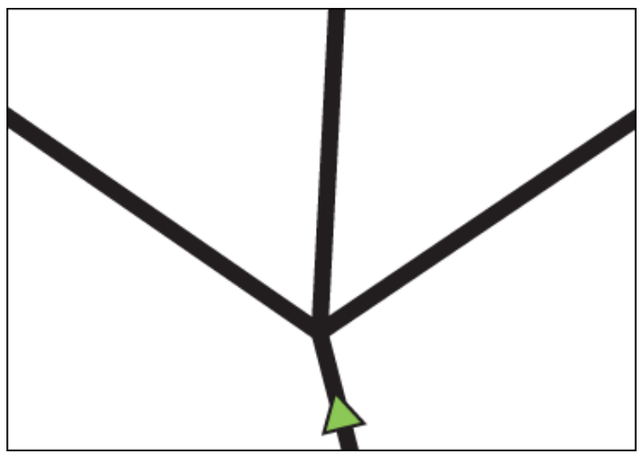
Visual Search Study:
Stimuli

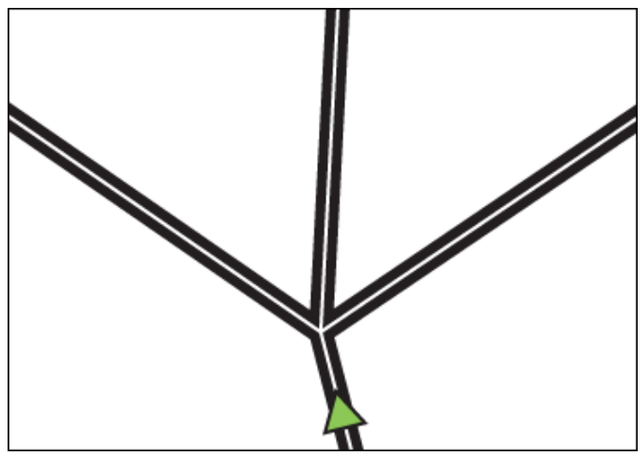
- To create the stimulus for each trial, we selected two renditions out of the 14 and placed them in 2 of 3 position
  - One used as target, the other used as distracter

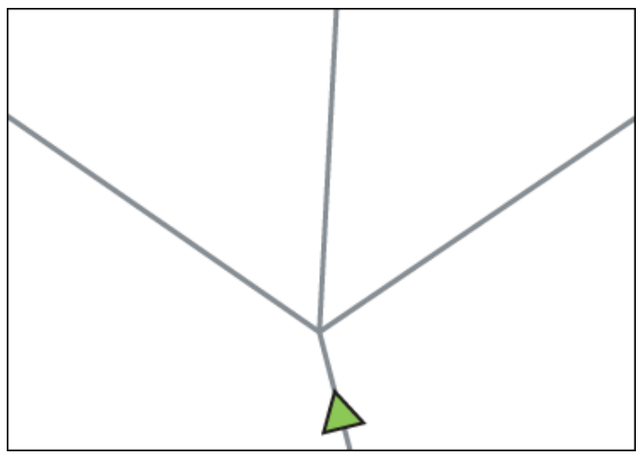


Visual Search Study:
Stimuli

- 3 different type of road renditions were employed
  - e.g., local road, highway, and intersection road







Visual Search Study:
Stimuli

- 3 different type of road renditions were employed
  - e.g., local road, highway, and intersection road
- Trials covered every target-distracter pair for total of 182 (=14x13)

Visual Search Study:
Stimuli

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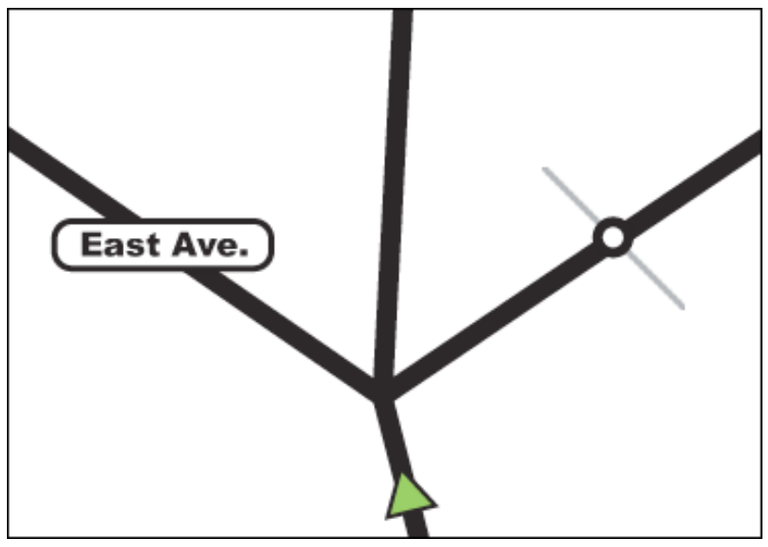
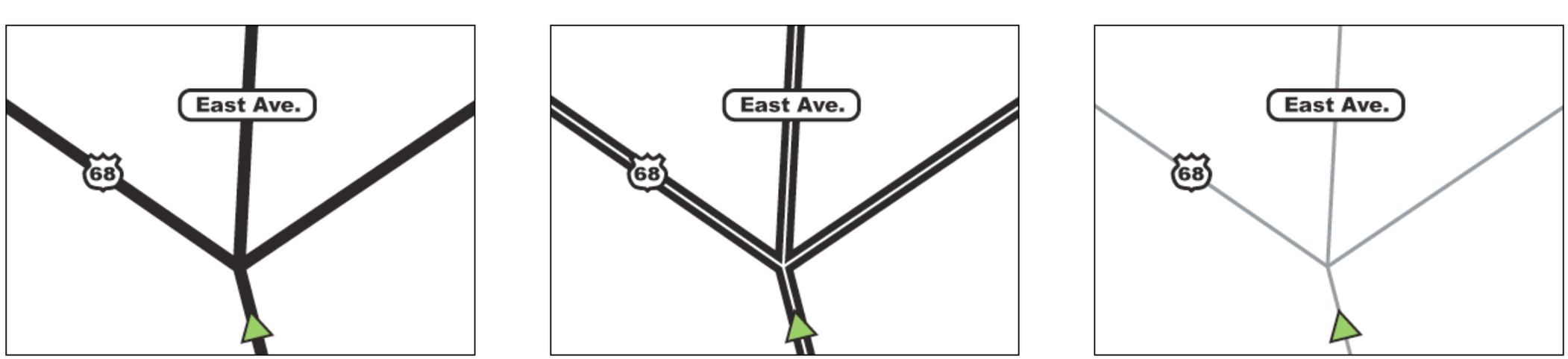


Visual Search Study:
Stimuli

- And then 3 road types were multiplied: total trials are 546 (=182x3)



- The placement of selected renditions in the road positions and ordering of trials was randomized

Visual Search Study:
Result and Discussion

- McDonald's logo was used for manipulation check
- Overall, highly salient as expected
  - because of its distinctive shape and color scheme makes it likely to induce pop-out effects
  - eliminated this rendition from the remainder of the analysis to avoid skew

Visual Search Study:
Result and Discussion

- For analysis, we categorized the renditions:

	Text	Number
Semantic	West Ave. East Ave.	36 68 83

	Simple	Complex
Symbolic		

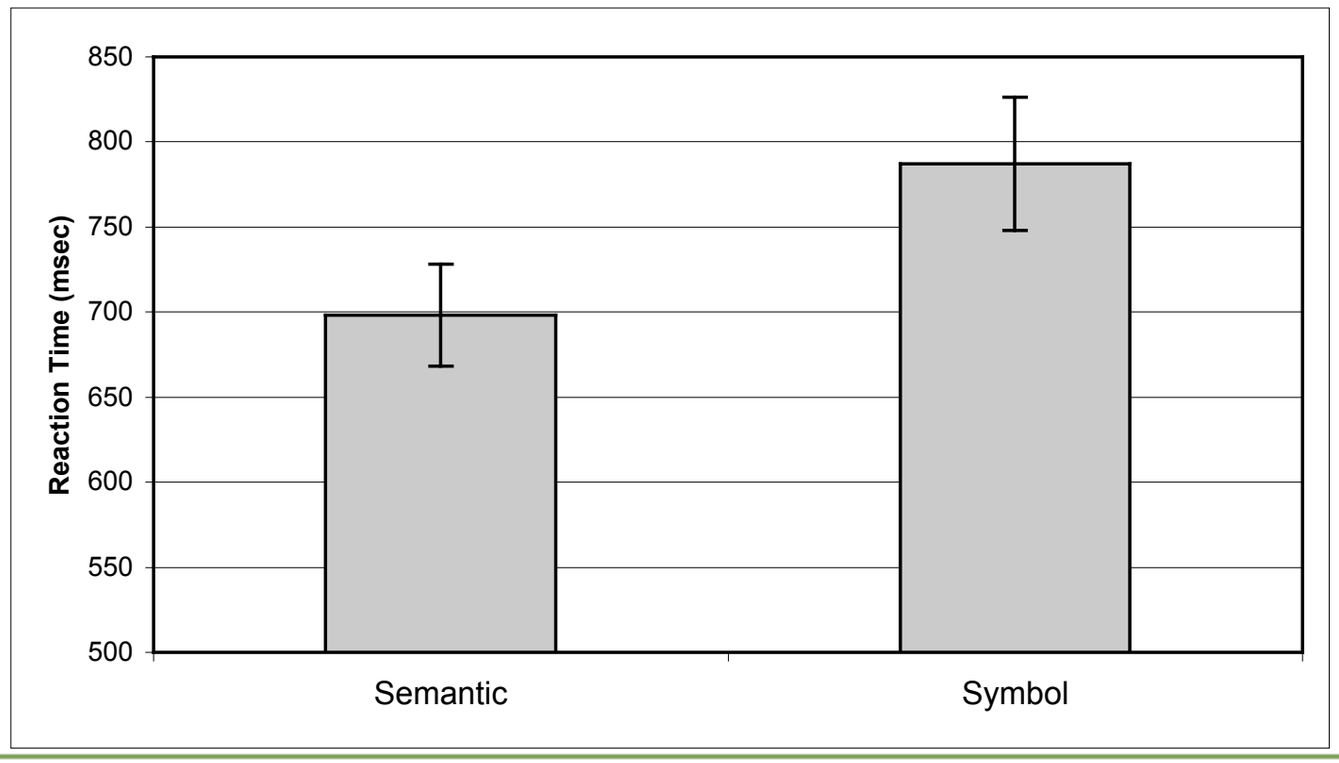
Colored	36
Black and White	68 83 West Ave. East Ave.
Large	West Ave. East Ave.
Medium	36 68 83
Small	

Visual Search Study:
Result and Discussion

- Major findings...
  - "Semantic" renditions can reduce reaction time.
  - Pop-out effect was found with colored renditions.

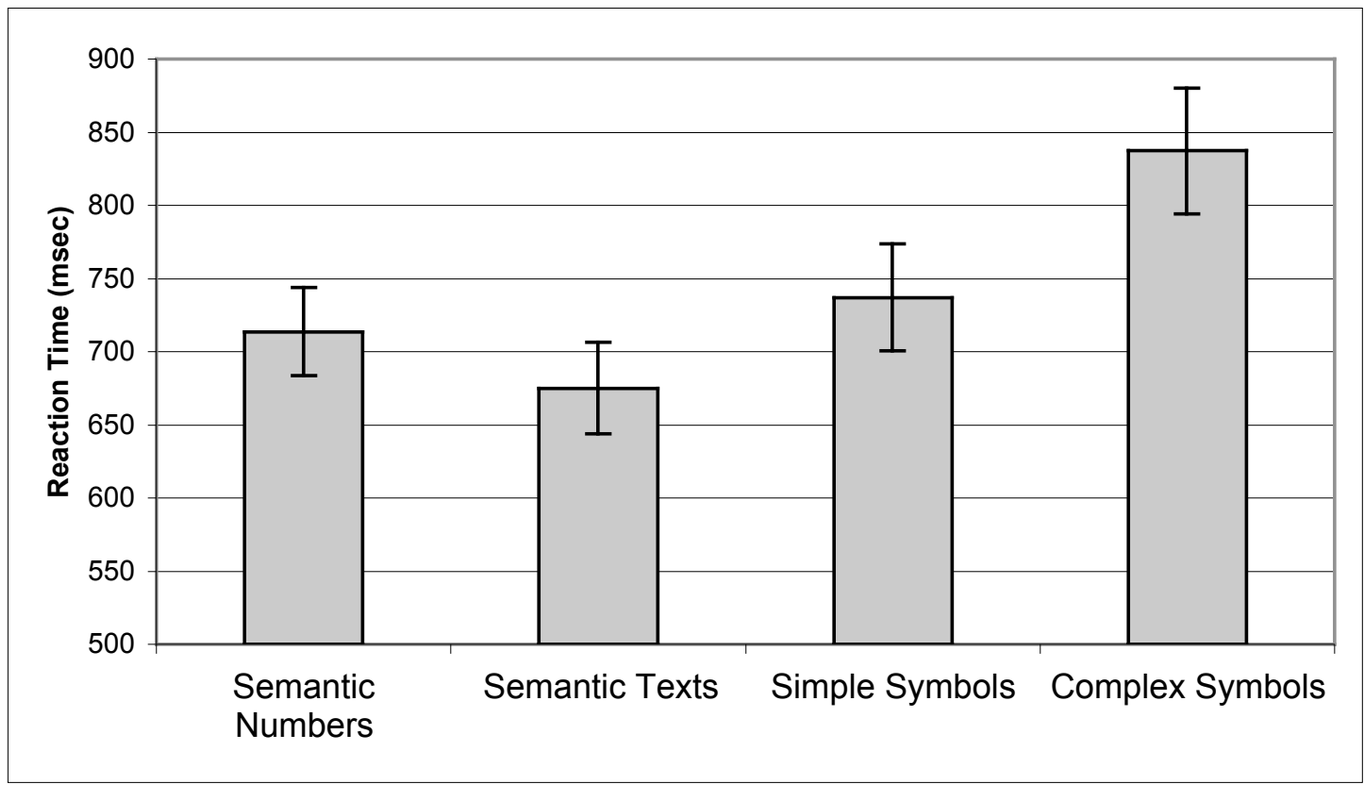
Visual Search Study:
Result and Discussion

- Comparison of the mean reaction times of semantic and symbolic renditions
  - Faster RT when searching for semantic renditions ($t(19)=-6.24$, $p<0.01$)



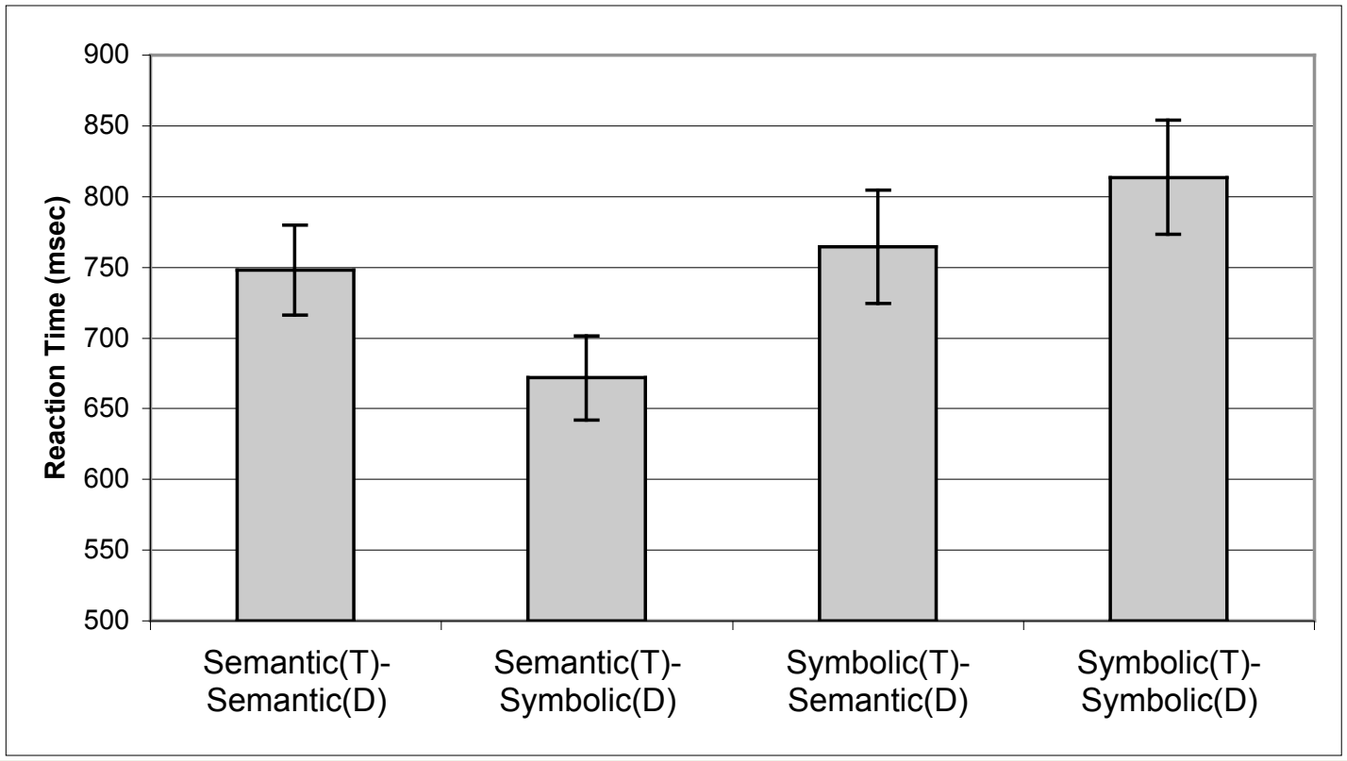
Visual Search Study:
Result and Discussion

- Comparison of finer semantic and symbol subcategories shows that reaction time for semantic text was the fastest, followed by semantic numbers, simple symbols and complex symbols ($F(3,57)=39.11$, $p<0.01$)



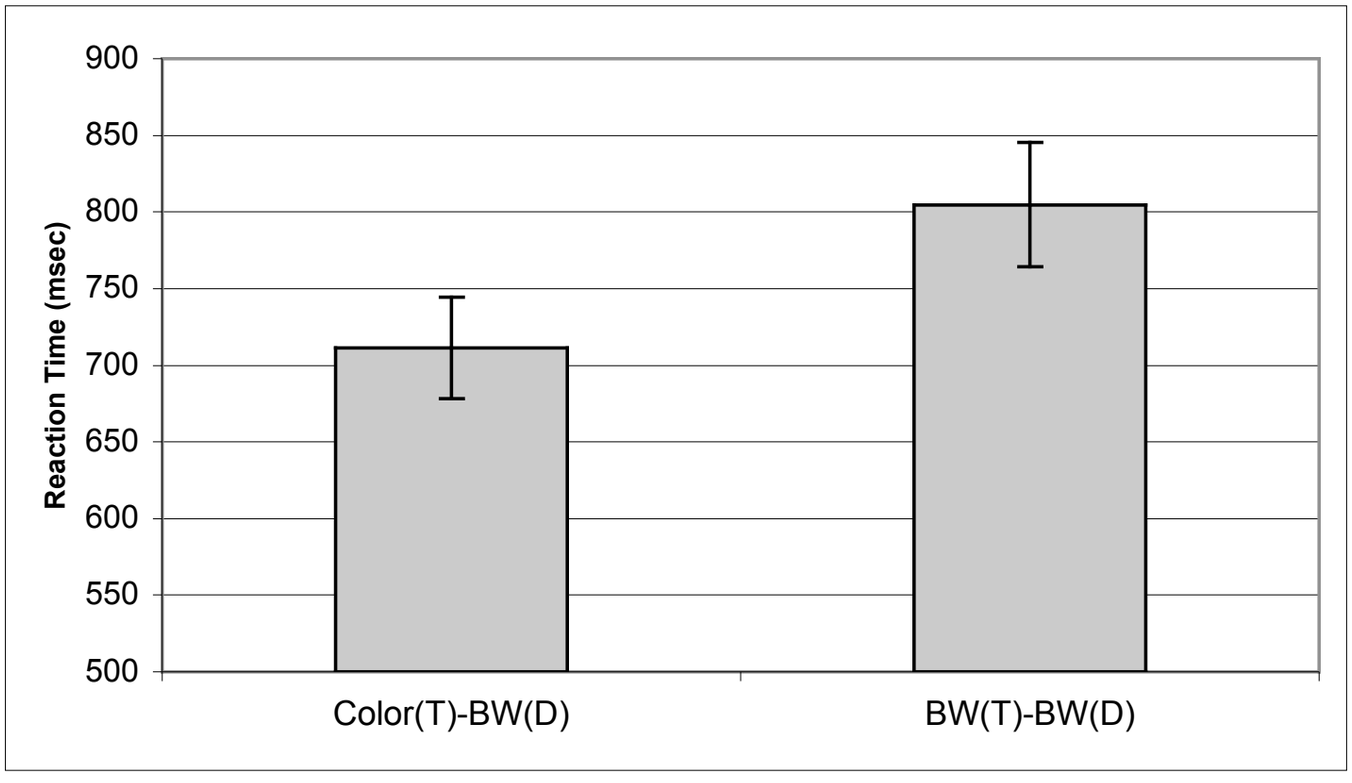
Visual Search Study:
Result and Discussion

- Comparison of target-distracter combinations:
  - Semantic(T)-Semantic(D), Semantic(T)-Symbolic(D), Symbolic(T)-Semantic(D), Symbolic(T)-Symbolic(D)
- RT was faster when semantic renditions were involved.
- If the target and distracter were of the same rendition type, then RT was increased
- ($F(3,57)=35.10$, $p<0.01$)



Visual Search Study:
Result and Discussion

- Prior research found that if clear pop-out occurs in a search task, RT is consistently fast no matter how many distracters are present (Goldstein 2002)
- Pop-out effect has also found in our result ($t(19)=7.79, p<0.01$)



Visual Search Study:
Result and Discussion

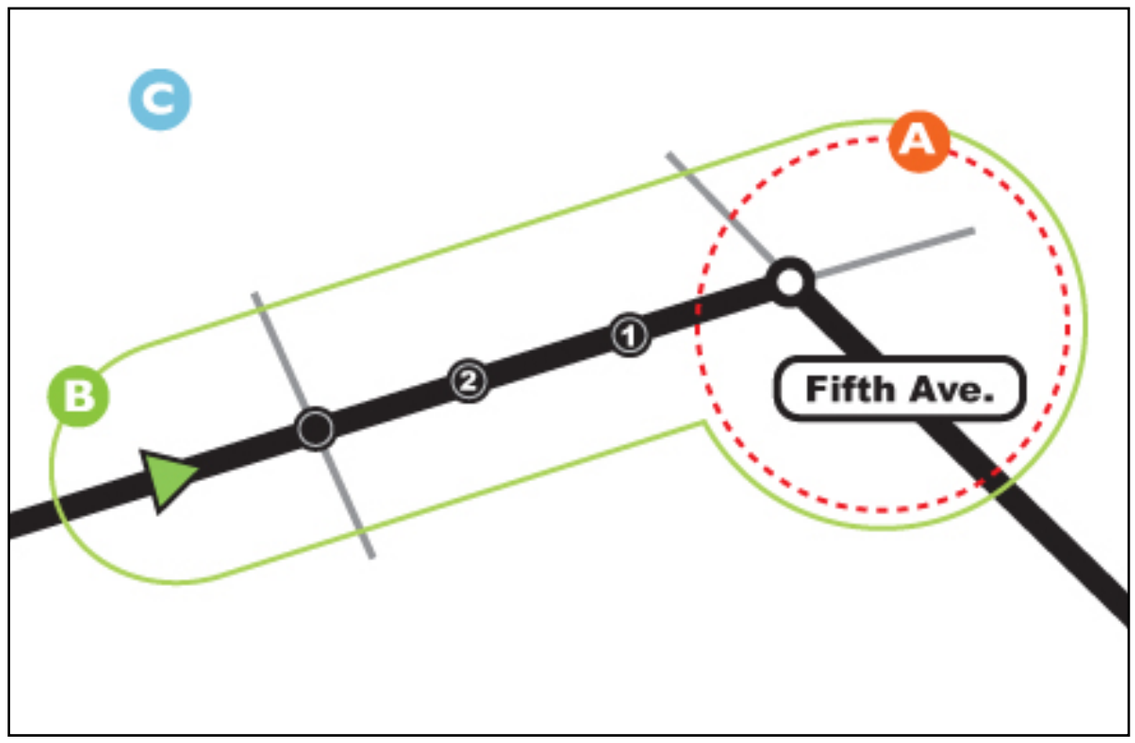
- However, size was not effective as pop-out.
  - Accordance with other research on bottom-up search (Baldassi and Burr 2004; Julesz 1984; Treisman 1896; Treisman 1998)
- No interaction effect between road types, semantic and symbolic renditions.

Design Implications:
Using Importance Difference

- In any given situation, not all information in the display will be of equal importance
  - by using the most salient and attention demanding display elements only for the likely high importance items, while lowering the salience or even removing others, we can expect to achieve a perceptually efficient display

Design Implications:
Using Importance Difference

- With the result, we generated simple diagram of using different importance of renditions
  - Semantic renditions should be used primarily for important areas (region A and sparingly in region B)
  - Symbolic renditions should be used in area that need less visual salience (region B and occasionally in region C)
  - Pop-out inducing renditions should be used very sparingly and only in locations of most likely current interest



Overview

- Navigation Study and Related Work
- Visual Search Study
- **Design Principles**
- Design of MOVE
- Evaluating Prototype Design

Continuing Work

- Implementation of the MOVE System
- Evaluating the Final System
- Contribution and Schedule

Design Principles

- Developed design principles based on navigation studies and review of existing systems and cartography.

1. Abstraction
2. Dynamics
3. Minimal Interaction

Design of MOVE

- Abstraction
  - Not every road detail is important for navigation
  - Abstraction by map generalization can enhance map reading
- Map Generalization
  - Feature Selection
  - Simplification/Smoothing
  - Relative Scaling
  - Displacement
  - Enhancement

Map Generalization

- Feature Selection
  - to determine which renditions to be drawn

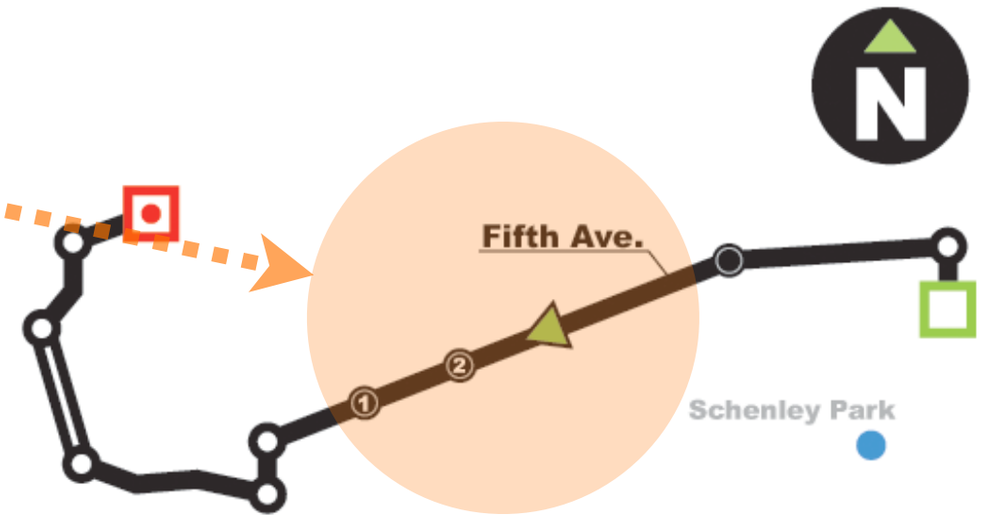
1. Original Route Map

2. MOVE Route Map

Map Generalization

- Feature Selection
  - to determine which renditions to be drawn

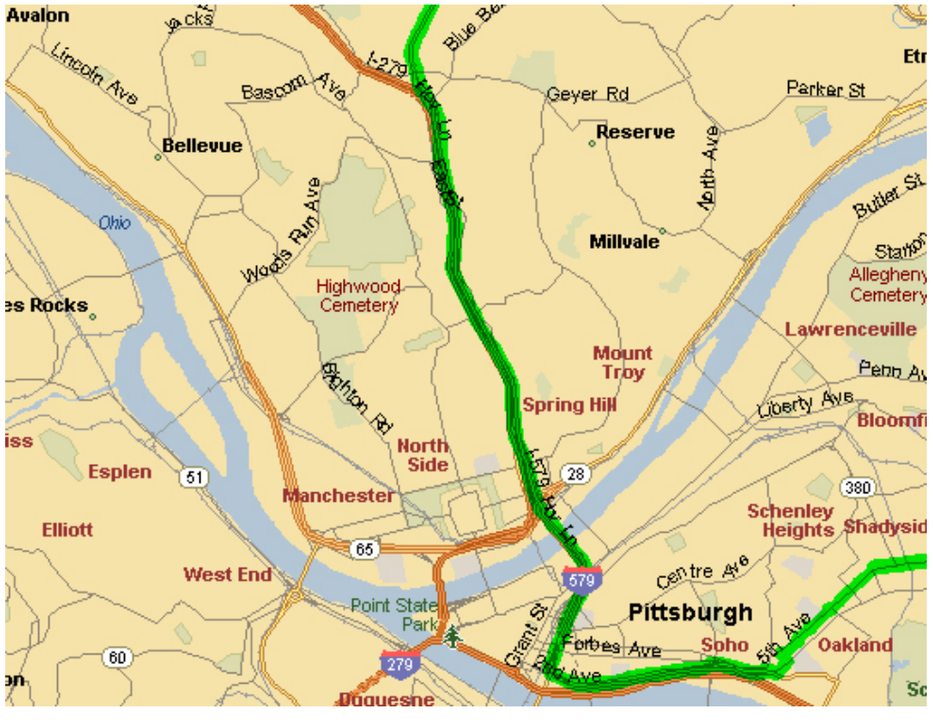
1. Original Route Map



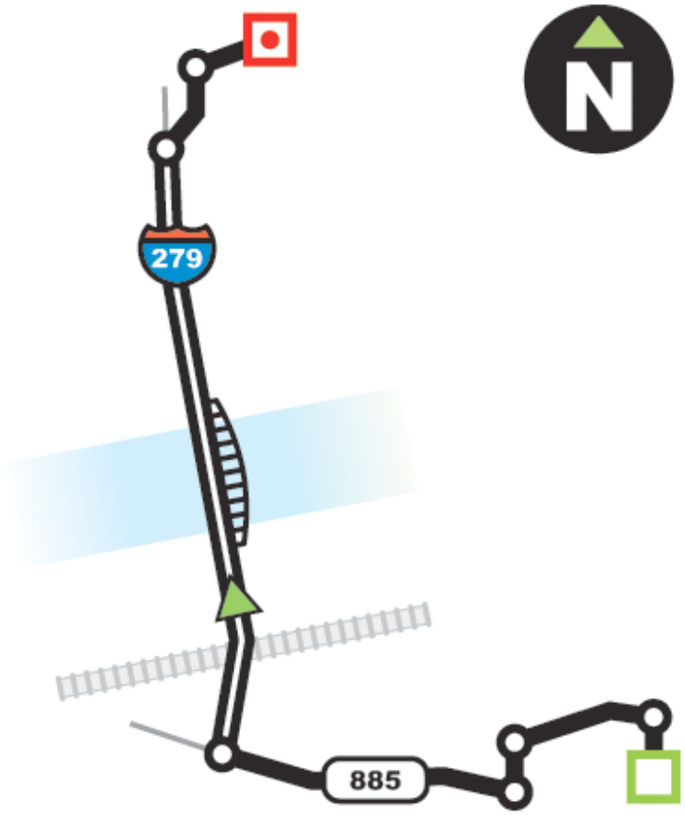
2. MOVE Route Map

Map Generalization

- Simplification/Smoothing
  - change road length, and shape



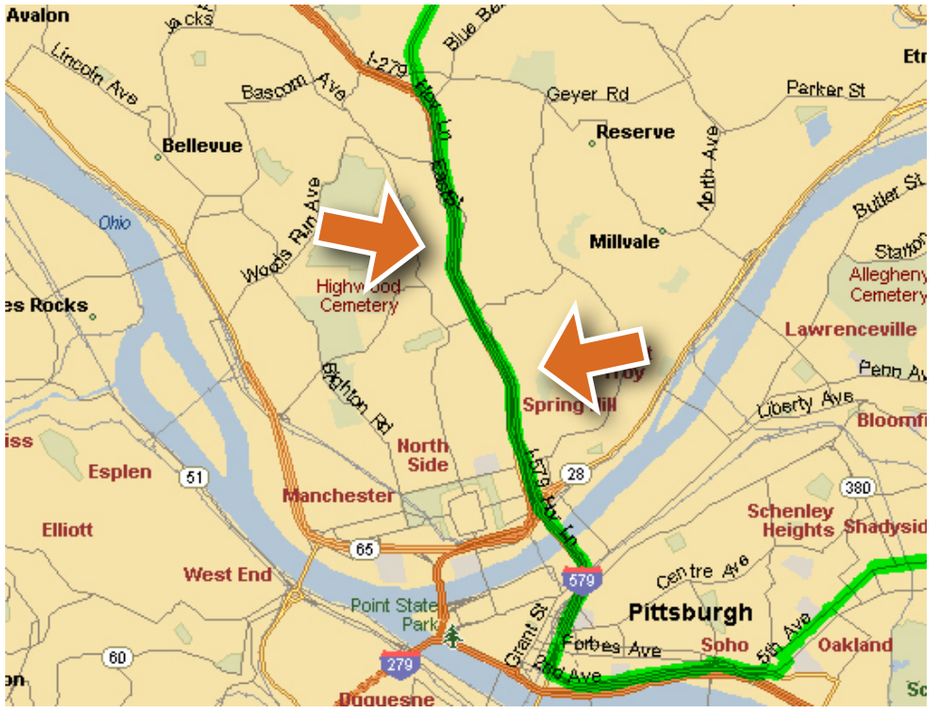
1. Original route



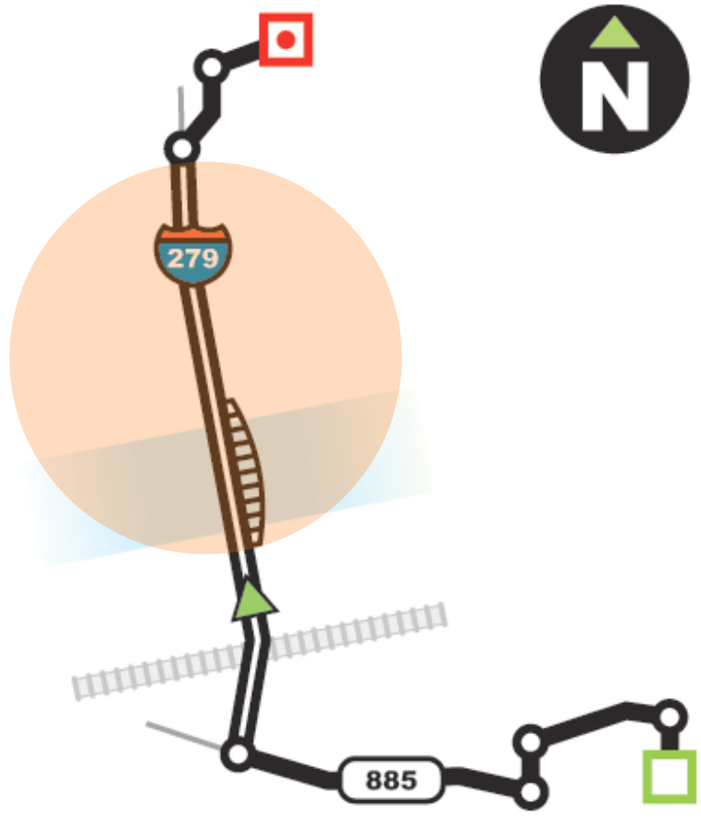
2. MOVE Route Map

Map Generalization

- Simplification/Smoothing
  - change road length, and shape



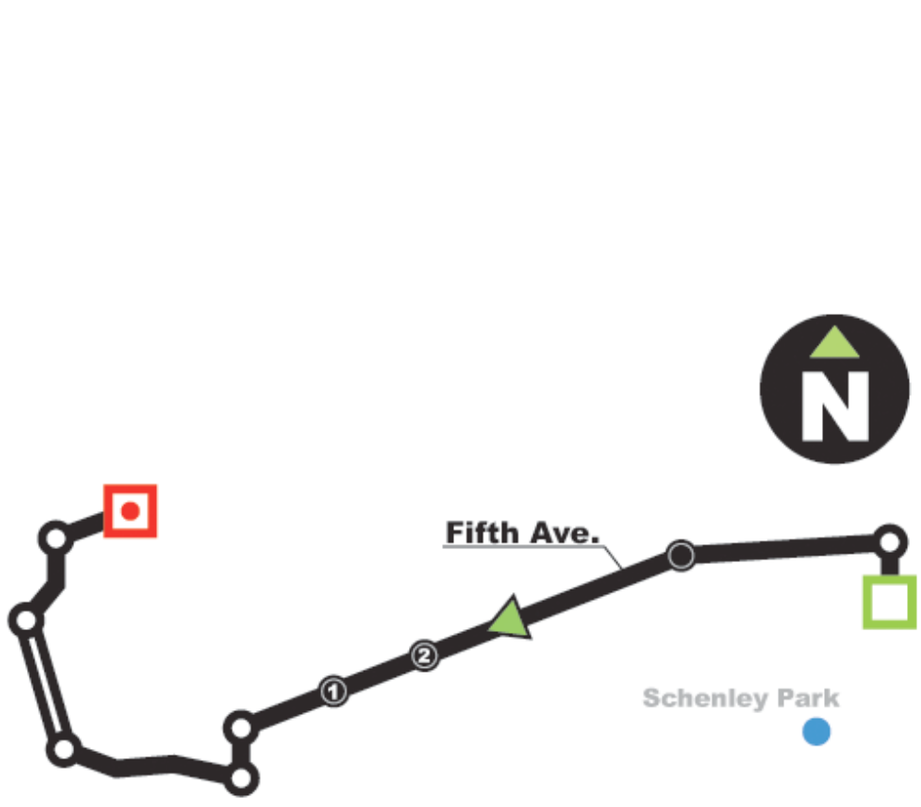
1. Original route



2. MOVE Route Map

Map Generalization

- Relative Scaling
  - relative scale factor for each feature



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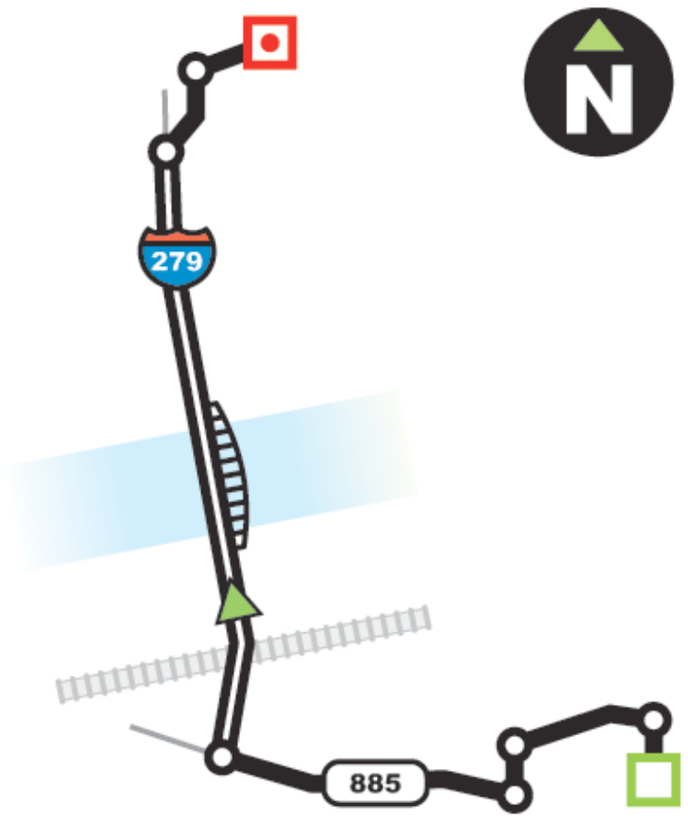

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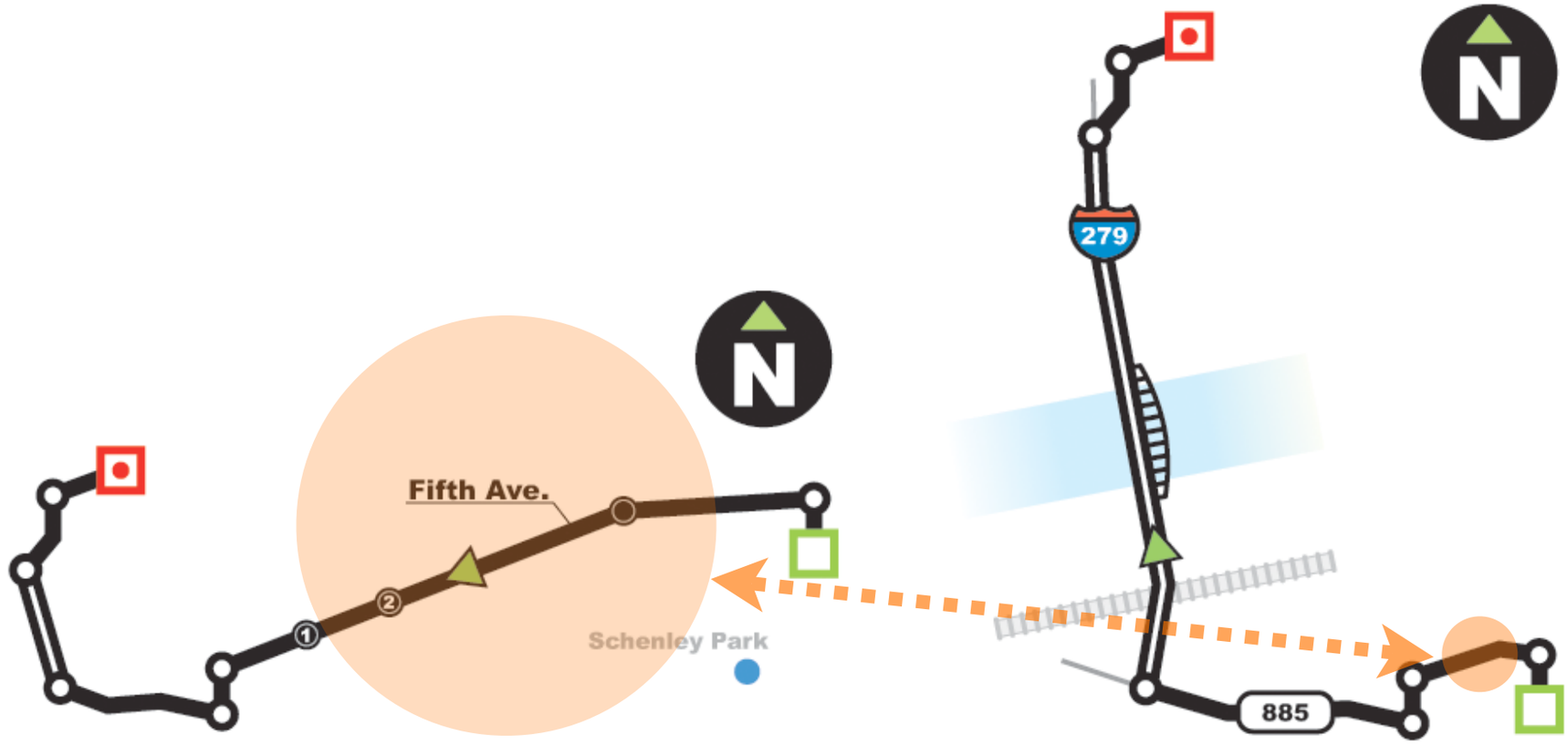
Map Generalization

- Relative Scaling
  - relative scale factor for each feature

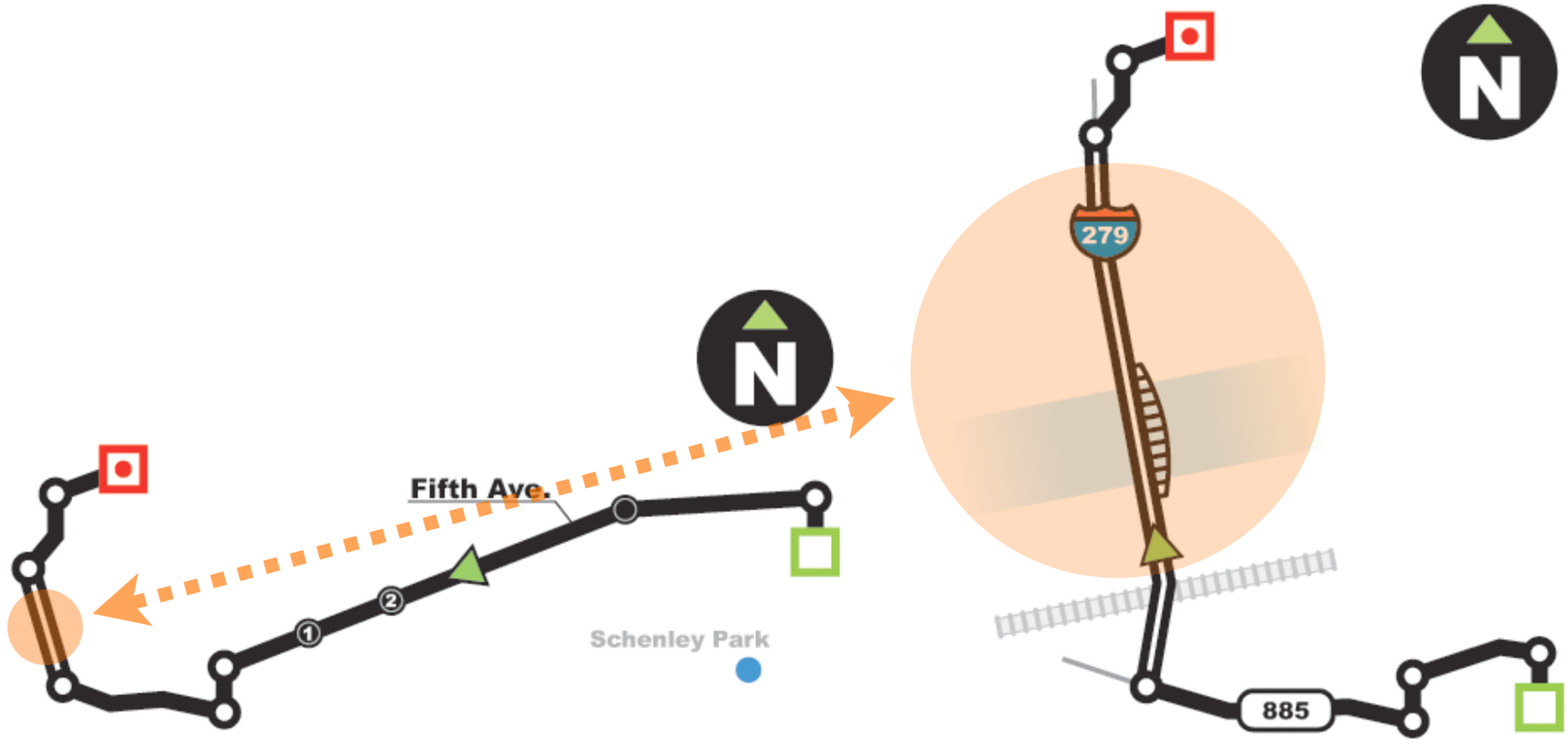


1. MOVE Route Map

2. MOVE Route Map

Map Generalization

- Relative Scaling
  - relative scale factor for each feature

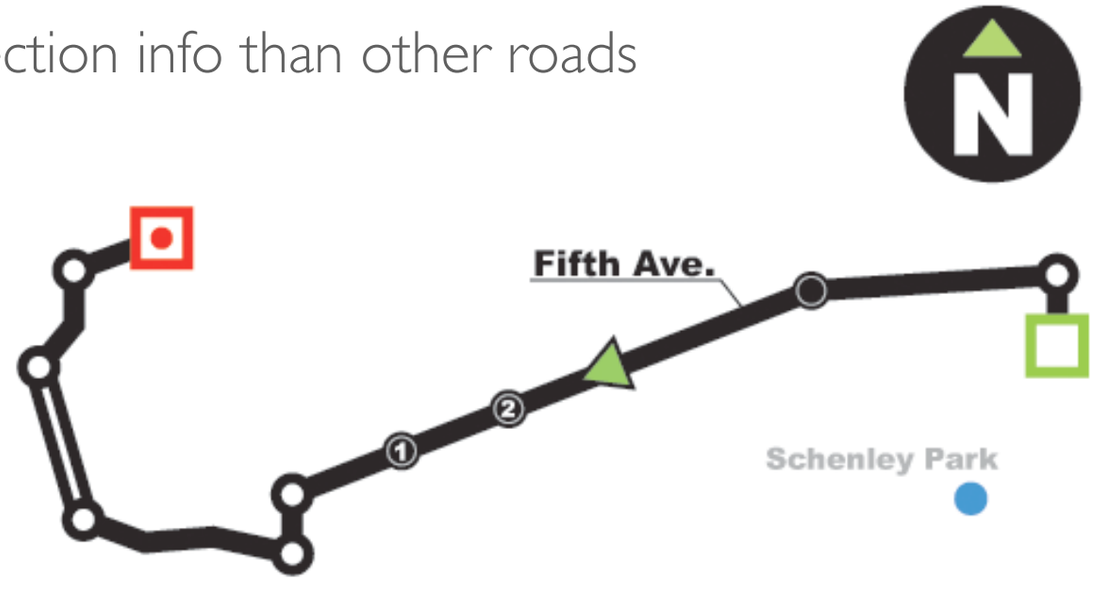


1. MOVE Route Map

2. MOVE Route Map

Map Generalization

- Displacement
  - **to avoid interference of features**
    - road label moved up to avoid landmark label
- Enhancement
  - **selectively increase detail**
    - Fifth Avenue has more detailed intersection info than other roads



Overview

- Navigation Study and Related Work
- Visual Search Study
- Design Principles
- **Design of MOVE**
- Evaluating Prototype Design

Continuing Work

- Implementation of the MOVE System
- Evaluating the Final System
- Contribution and Schedule

Design of MOVE

- Dynamic Information Interaction
  - Presenting information well can compensate for small screen
  - MOVE uses the most detail to render the section of the route that the driver is traversing

Design of MOVE

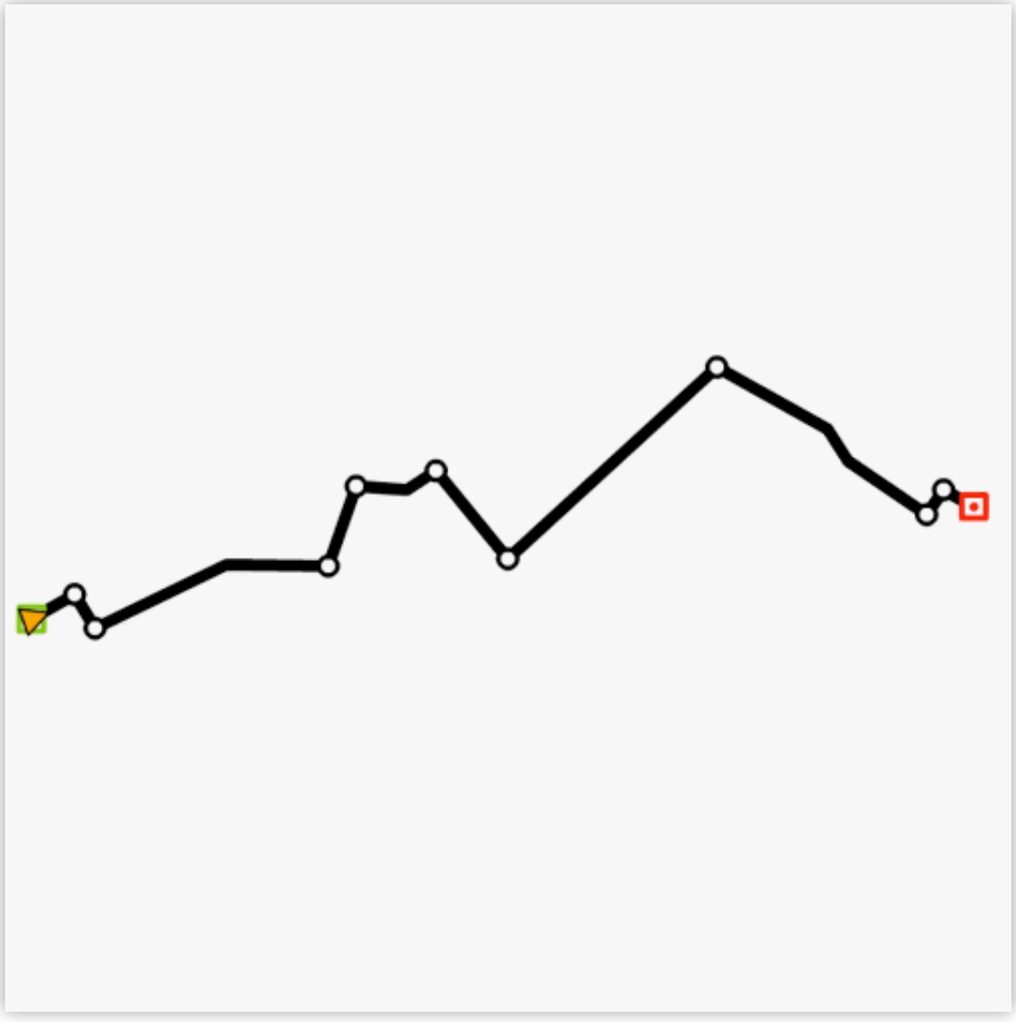
- Designed 4 presentation styles
  - Zoom in Context (ZC)
  - Route Scrolling (R)
  - Zoom in Context + Route Scrolling (ZC+R)
  - Zoom in Context + Overview (ZC+O)

MOVE Presentation Styles

- Zoom in Context (ZC)

  + Driver can see entire route

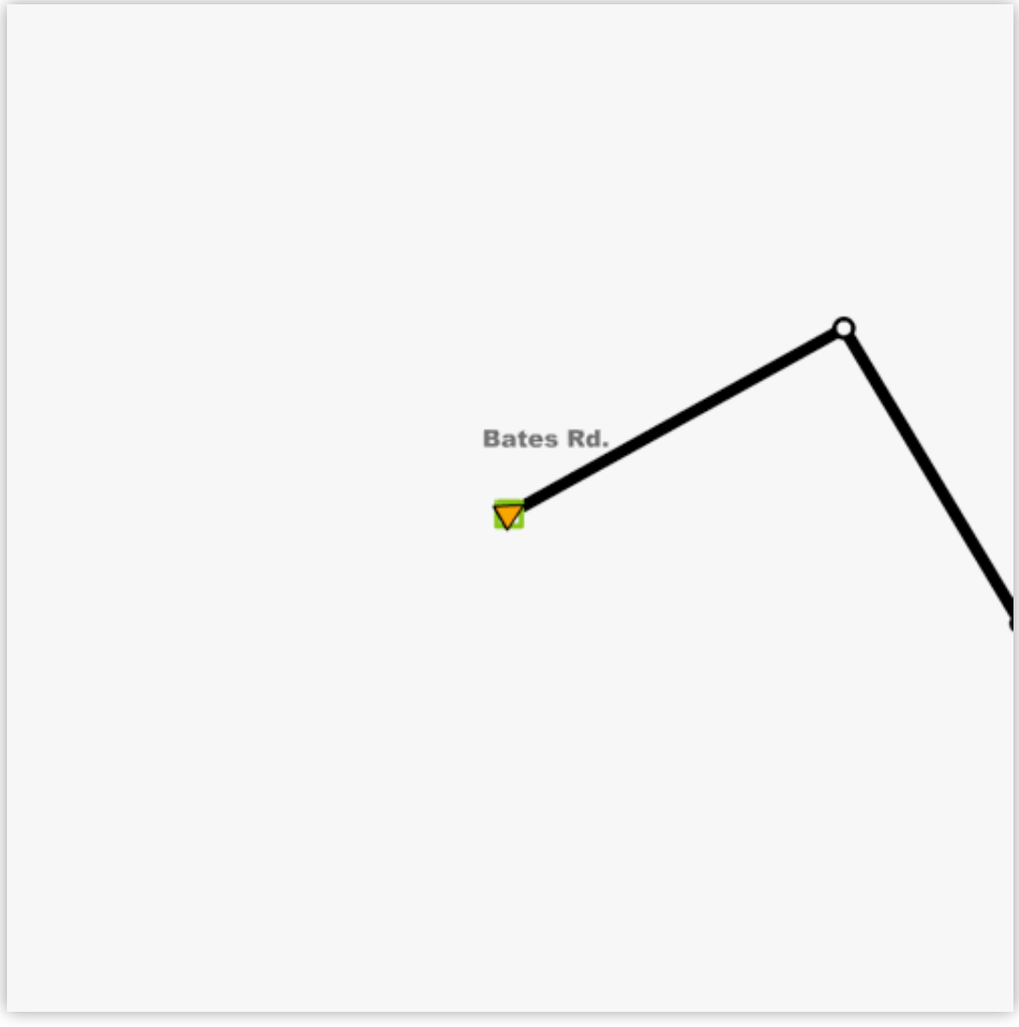
  – Target position move back and forth



MOVE Presentation Styles

- Route Scrolling (R)

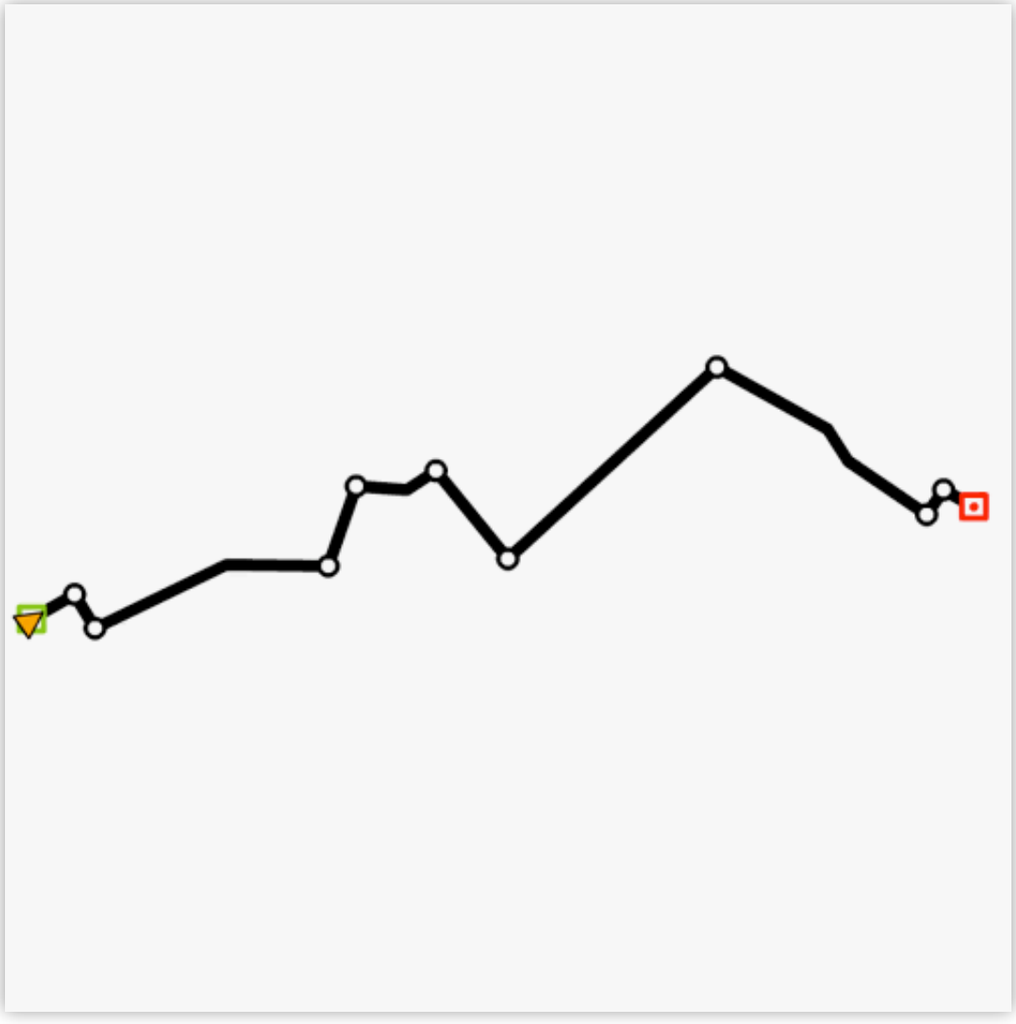
  + Target position is always in the center of the screen
  – Driver cannot see entire route



MOVE Presentation Styles

- Zoom in Context +
  Route Scrolling (ZC+R)

  + Driver can see the remaining route chunks
  – Driver cannot see entire route
  – Target position still move back and forth

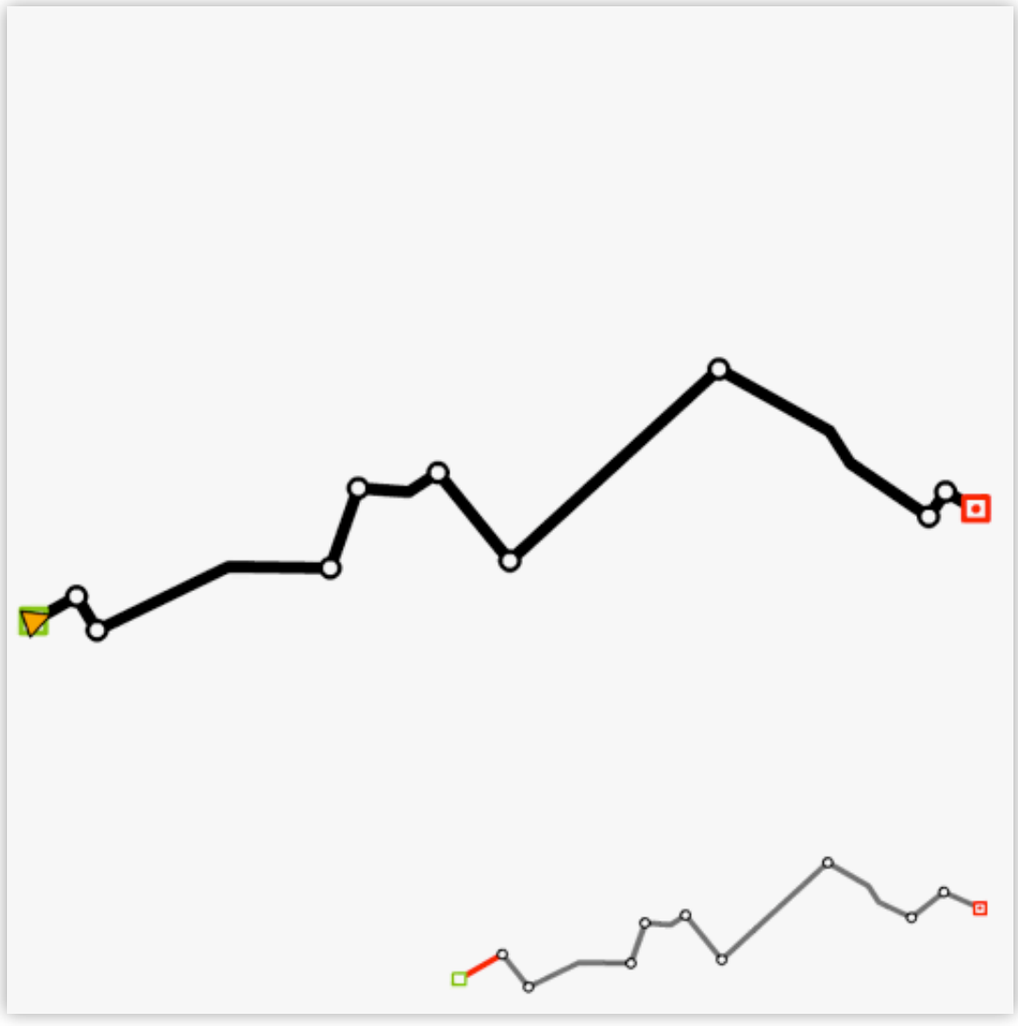


MOVE Presentation Styles

- Zoom in Context + Overview (ZC+O)

  + Driver can see both entire route and the detailed route at once

  – Two target positions make it complicated



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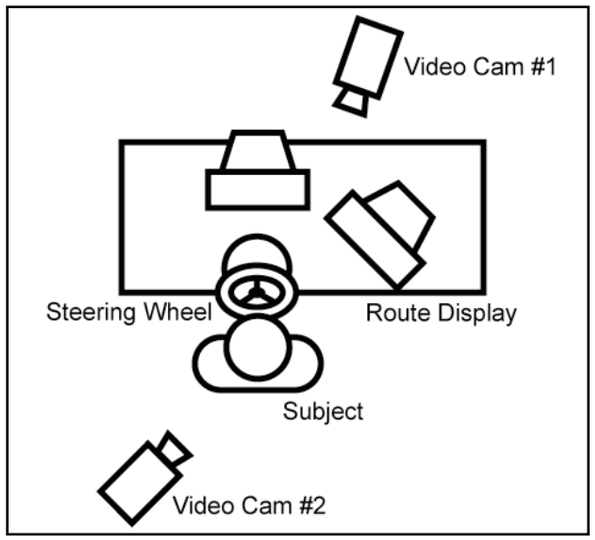
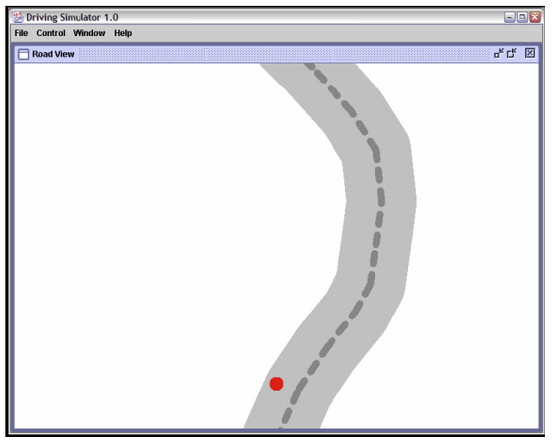
Evaluating MOVE Design

- Purpose: to evaluate feasibility and effectiveness of prototype design
- Map reading performance study
  - compare MOVE with the most optimized current static map (LineDrive)
- Hypothesis:
  MOVE presentation methods can reduce the number of glances and fixation times to comprehend information
  → *reduce perceptual load*

Evaluating MOVE Design

- Study Overview
  - Dual task study
  - Simple simulated driving task to saturate attention *plus* navigation display
- Subjects were told to maintain a central position on the road and prompted to glance at the navigation system and verbally report what was seen.





Evaluating MOVE Design

- 20 participants (12M, 8F; aged 19-56)
- Within subject study: performed all conditions
- **Conditions** (counter balanced)
  - Baseline - check primary task performance without map display
  - Static Route Map: LineDrive
  - 4 MOVE presentation styles (ZC, ZC+R, R, ZC+O)
  - ZC w/o car location cursor - to compare with static map

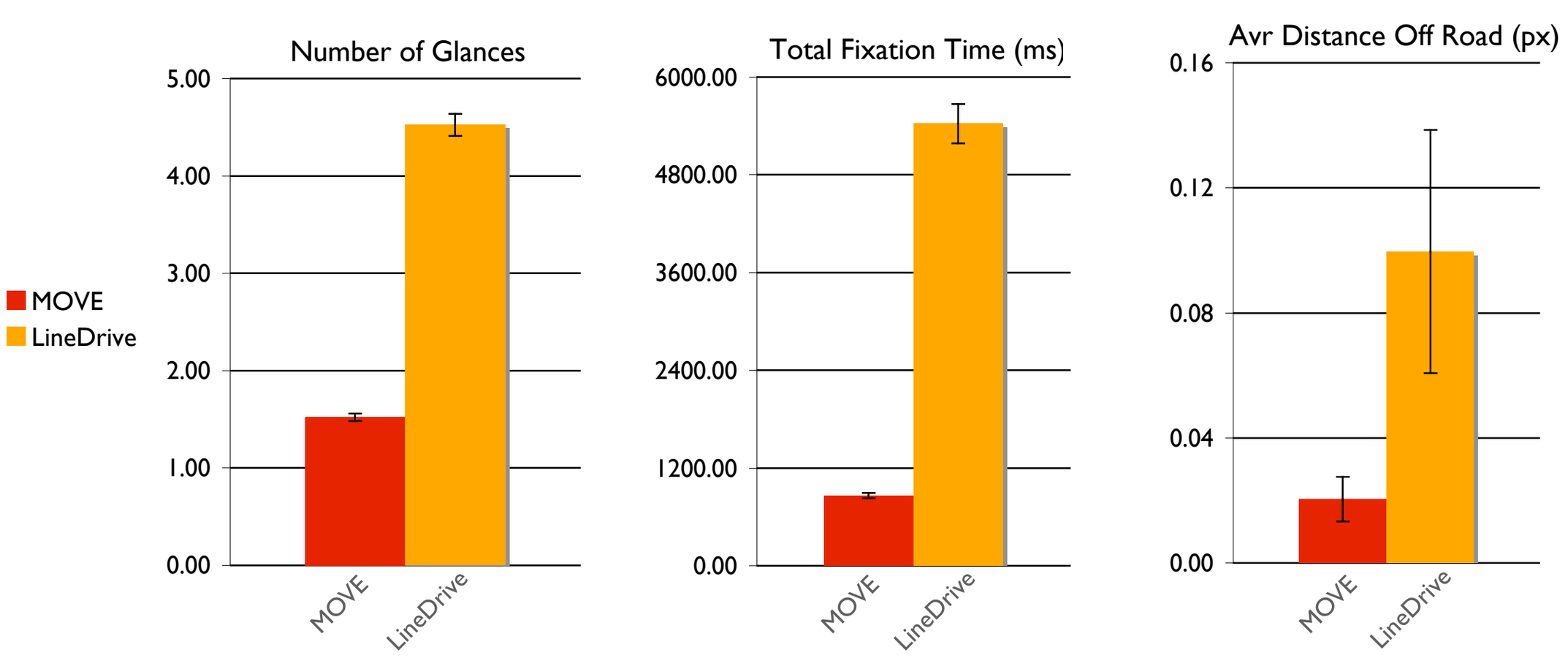
Evaluating MOVE Design

- Measures
  - Total number of glances per task
  - Total fixation time
  - Average distance off the road

Evaluating MOVE Design

MOVE vs. LineDrive (Lower is better)

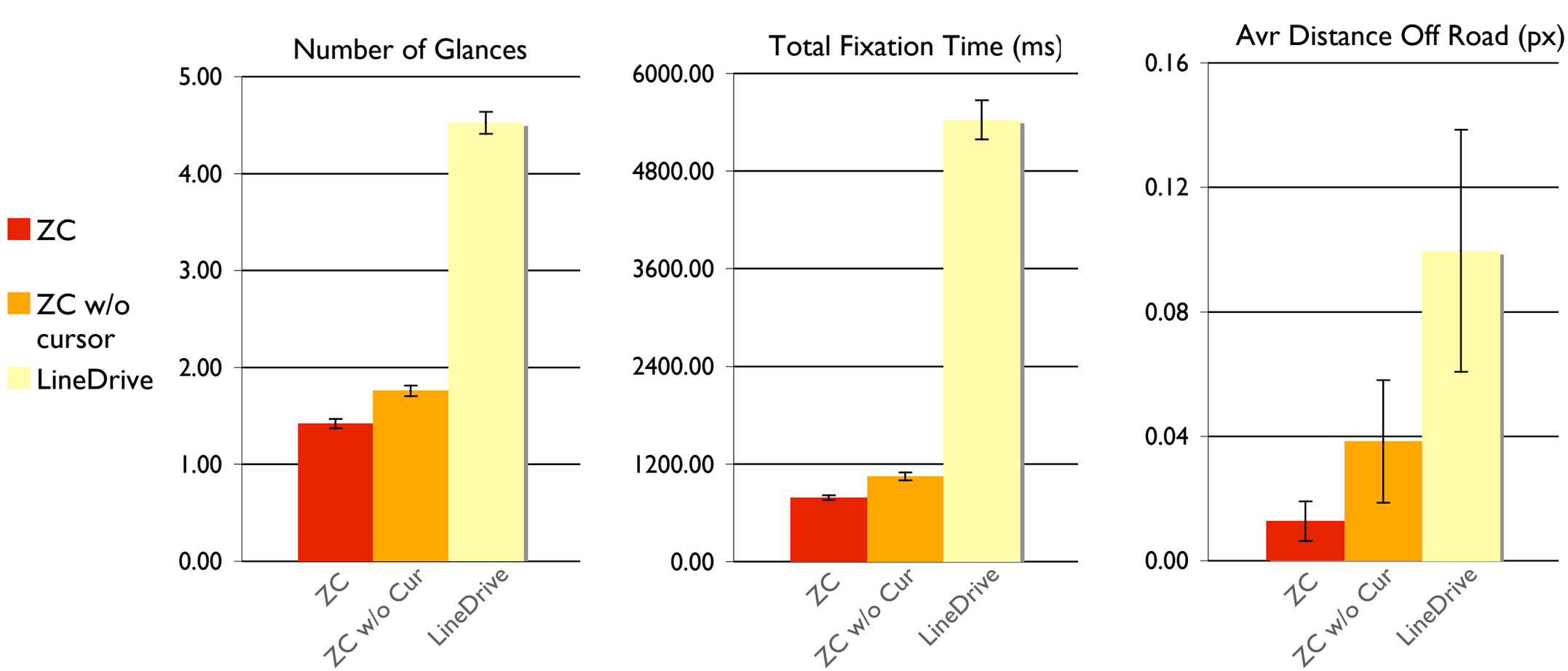
All significant at 5% significance level



Evaluating MOVE Design

Merit of Cursor (Lower is better)

All significant at 5% significance level

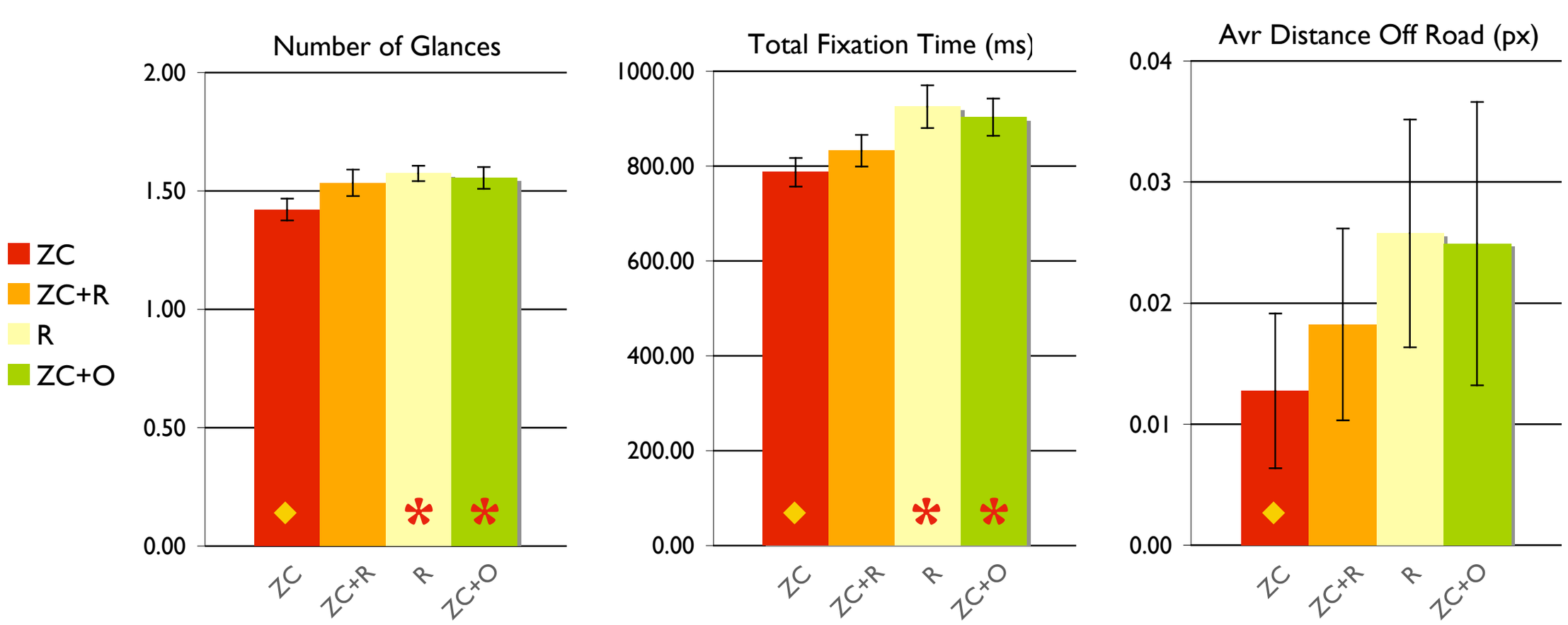


Evaluating MOVE Design

MOVE 4 Presentation Styles (Lower is better)

◆ used for baseline comparison

* significant at 5% significance level



Evaluating MOVE Design

- Explanation of under performing designs:
  - Route Scrolling
    - Route was just moving, not zooming into the context
  - Zoom in Context + Overview
    - Two information sources (Route and Overview) make the map complicated.
    - Sometimes information within the route overlaps the overview, so position of overview will move.
  - These two conditions least effective: not using screen real estate effectively

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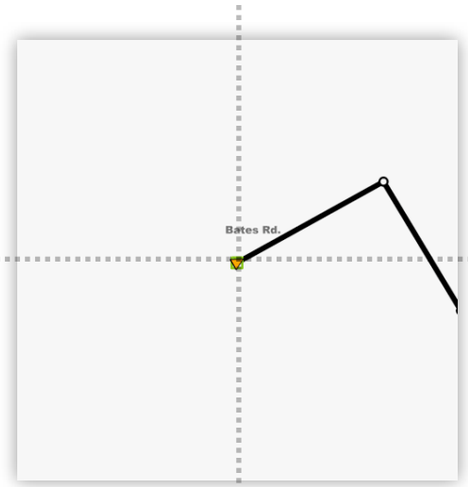

Route Scrolling

Evaluating MOVE Design

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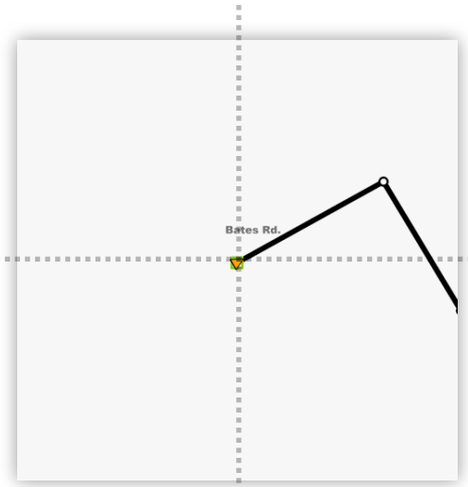
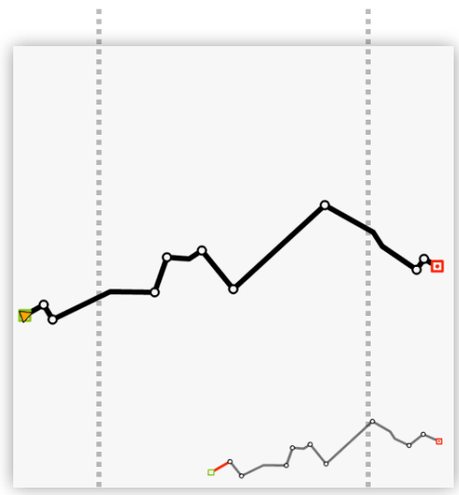


Route Scrolling


Zoom in Context + Overview

Overview

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- **Implementation of the MOVE System**
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Implementation of MOVE

- Four implementation processes.
- Planned to address five map generalization techniques.
  - *Simplification/Smoothing, Relative Scaling, & Enhancement* → **Road Layout**
  - *Map Feature Selection* → **Rendition Selection**
  - *Map Feature Selection & Enhancement* → **Scoring Rendition**
  - *Displacement* → **Final Placement Tuning**

Road Layout

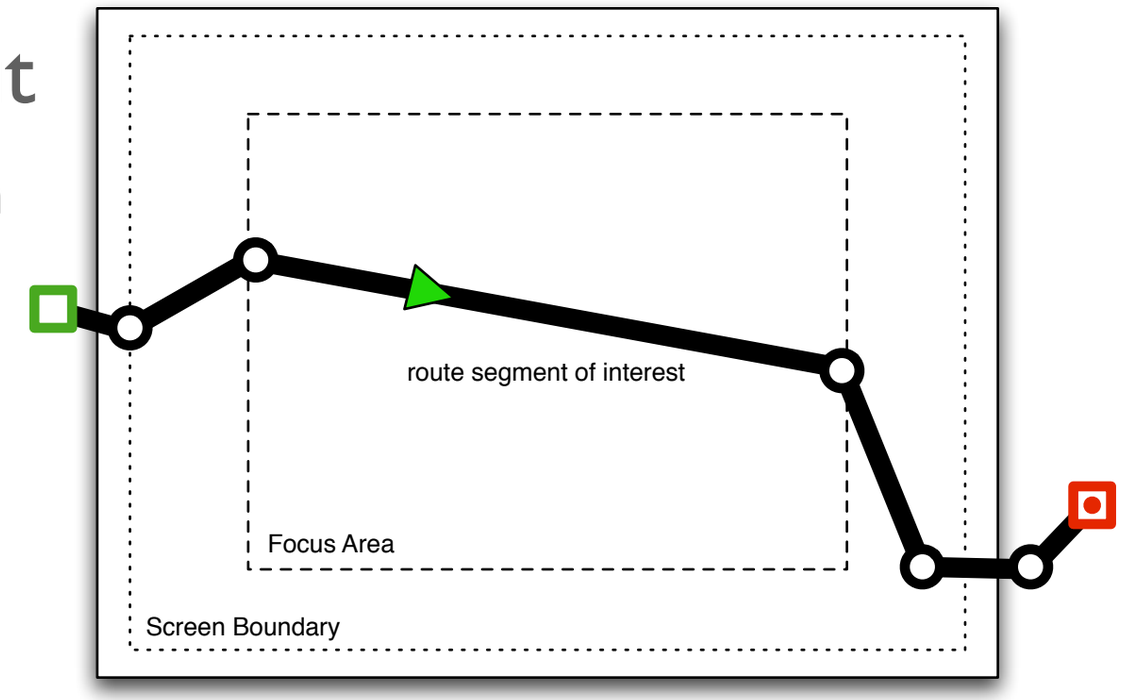
- To place a route within the space of the screen display
- To generate the entire route as simply as possible while making the importance portions of the route segment salient.

Road Layout

- We treat road layout as an optimization problem
  - optimization can smoothly handle exceptional cases
- Goal of optimization
  - Display the route within a given screen boundary, emphasizing the segment of interest without losing the entire context of the route.
    1. route segment of interest should occupy most of the screen real estate.
    2. the entire route should be displayed within the display boundary

Road Layout

- "Segment of interest"
  - corresponds sub-goal that people use for navigation.
  - could mean *a route segment containing car* or more segments depending on the situation.
- Internal areas for road layout
  - focus area: majority of the entire screen
  - screen boundary:
    slightly offsetting from
    the borders of the entire screen
    (safe margin)



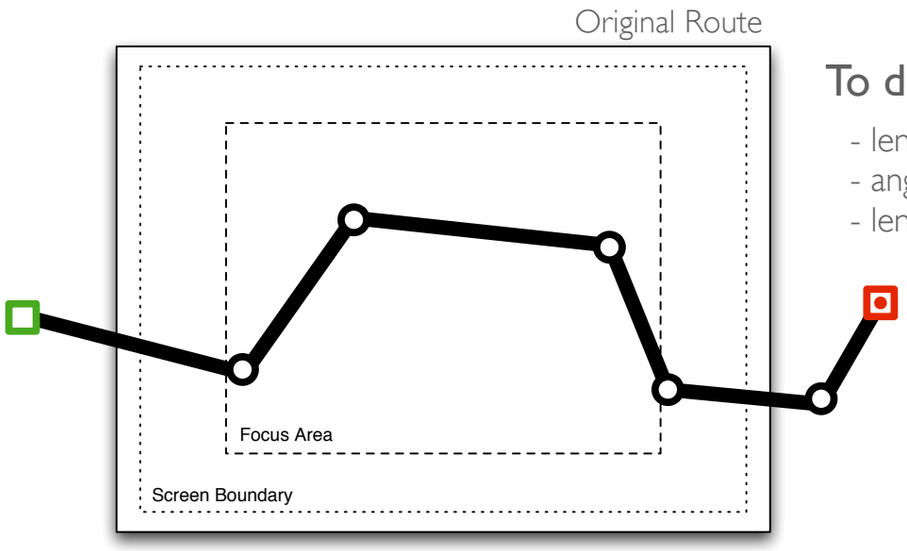
Road Layout

- Optimization process
  - uses **Simulated Annealing** (Kirkpatrick, Gelatt &Vecchi 1983)
    - **Simulated Annealing** is an iterative method to solve optimization problems of large scale, especially ones where a desired global extremum is hidden among many local extrema.
  - Similar to hill climbing method - heuristically good, but cannot find global extrema.
  - To avoid the local extrema, each step of the SA algorithm considers some neighbor solution of the current solution, and probabilistically decides between moving the system to the neighbor solution or staying put in the current solution.
  - SA has been proved its effectiveness and stability in many problems including the LineDrive.

Road Layout

- Optimization process
  - parameterized by two functions:
    - ***perturb_map_layout()***: randomly generates an iteration by modifying some of its values
    - ***score_map_layout()***: evaluates the iteration and returns a score of the iteration as a result of the evaluation

Road Layout by Optimization



To distort original route, randomly change:

- length of route segment of interest
- angle of route segment of interest
- length of remaining route segments

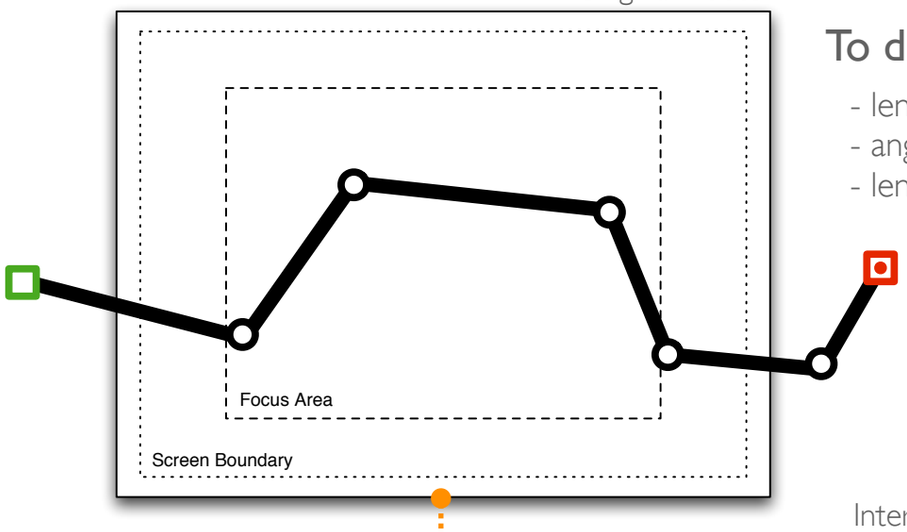
In each iteration of distortion, discard the iteration if...

- the whole route is bigger or smaller than screen boundary
- the route segment containing car is bigger or smaller than focus area
- the angle of route segment containing car is very different from original angle

.....

Road Layout by Optimization

Original Route



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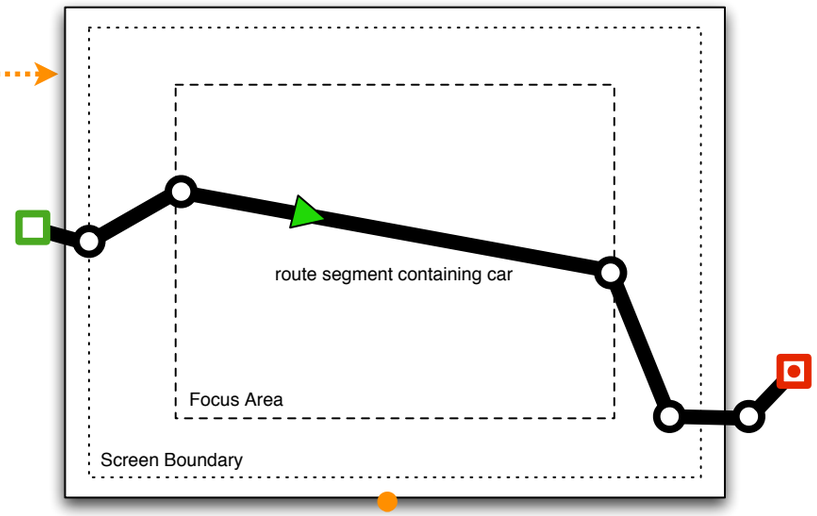
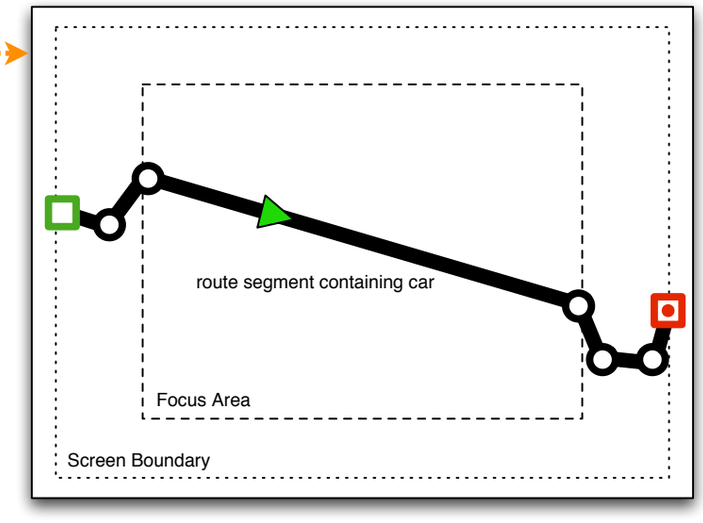
- length of remaining route segments

Intermediate Distorted Route



Final Distorted Route



In each iteration of distortion, discard the iteration if...

- the whole route is bigger or smaller than screen boundary
- the route segment containing car is bigger or smaller than focus area
- the angle of route segment containing car is very different from original angle

.....

Rendition Selection

- Rendition selection process takes the large information set of the original map and presents it in a less information demanding manner.
- Also achieved through the optimization with simulated annealing.
  - use two functions to find a final solution
    - ***perturb_rendition_selection()***: randomly selects a rendition and raise or lower its rendition choice to the one which is next higher or lower in salience.
    - ***score_rendition_selection()***: evaluates each iteration and eventually chooses a final solution minimizing the sum of score of given rendition selection.

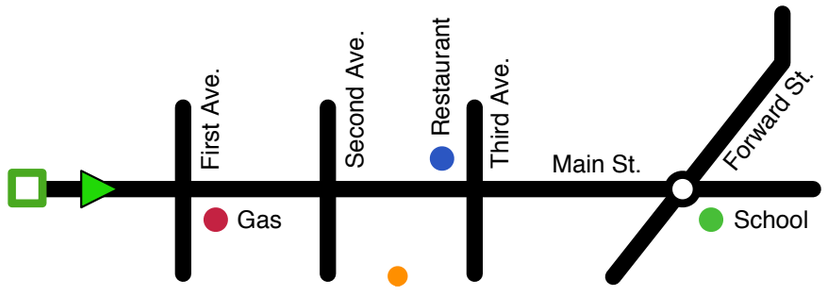
Rendition Selection

- The score of the current map's rendition selection can be calculated as follows:
  - Each map feature or layout decision has:
    - Communicative potential score (C)
    - Importance score (I)

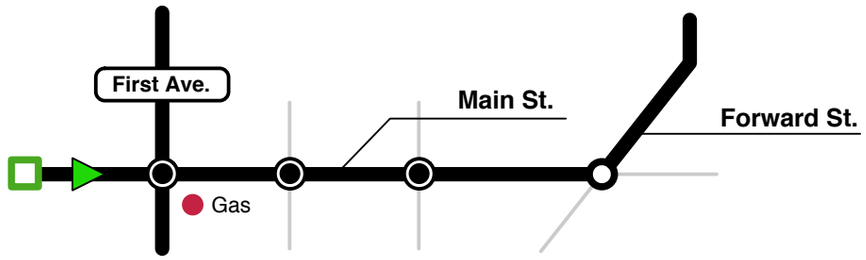
$$\sum_{S \in Route} C(Rs) * I(S)$$

where ***S*** is a route segment or feature
Rs is a rendition choice for segment ***S***
C(Rs) is communicative potential score for rendition choice ***Rs***
I(S) is importance score for route segment ***S***

Rendition Selection Process

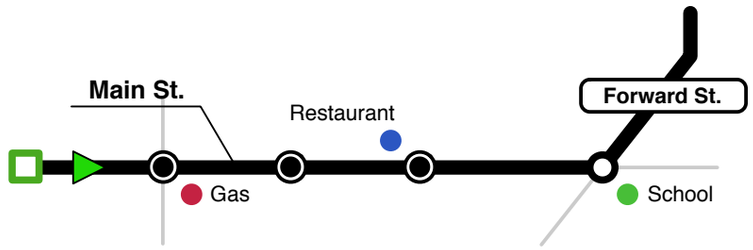


1st Iteration

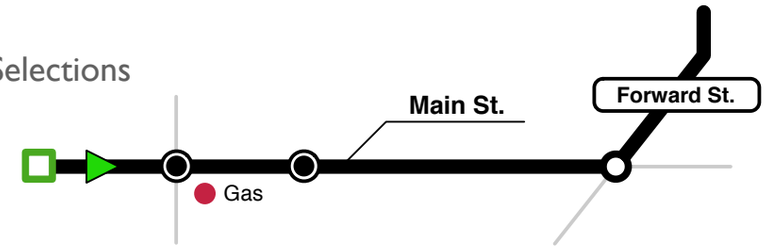


number of iterations

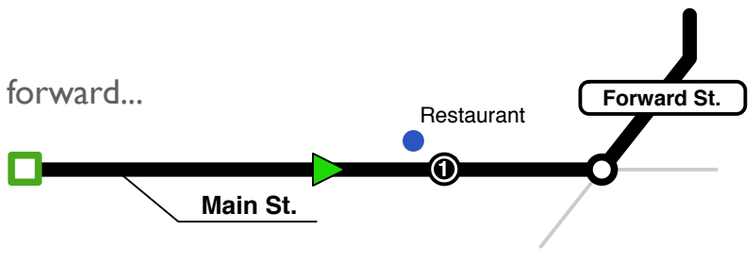
Nth Iteration



Final Rendition Selections

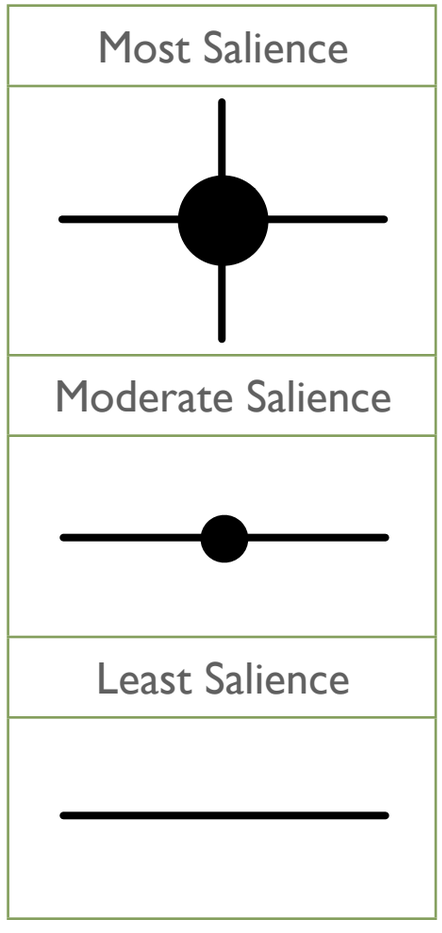


As vehicle moves forward...



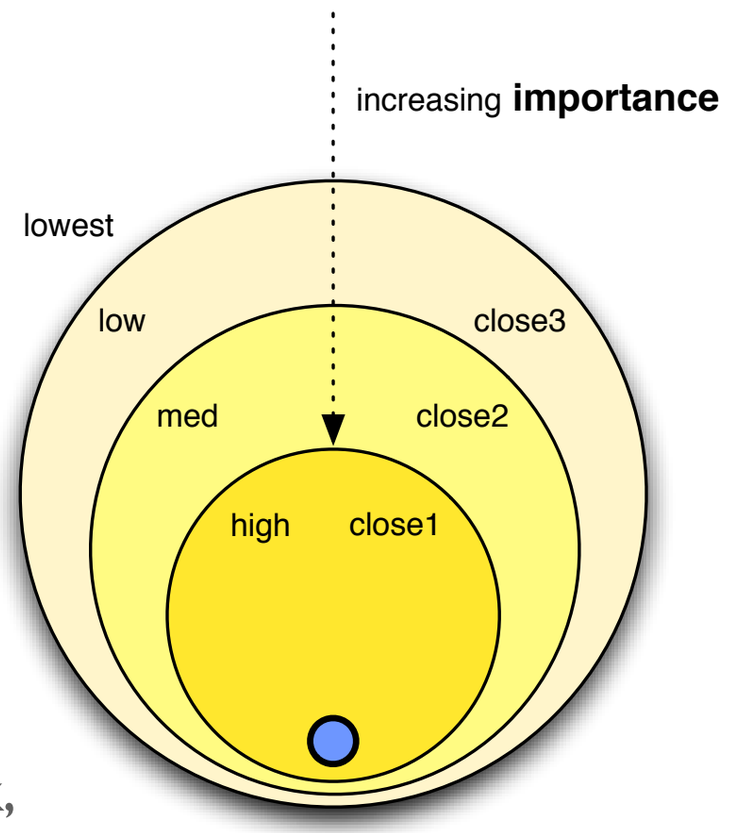
Scoring Renditions

- For the rendition selection process, each map rendition must be scored.
- Two types of scores:
  - ***Communicative Score***
    - how easily a rendition is delivered to a user.
    - fixed score.
  - ***Importance Score***
    - fluctuating score for each rendition that would be changed over the time as a vehicle traverses a route.



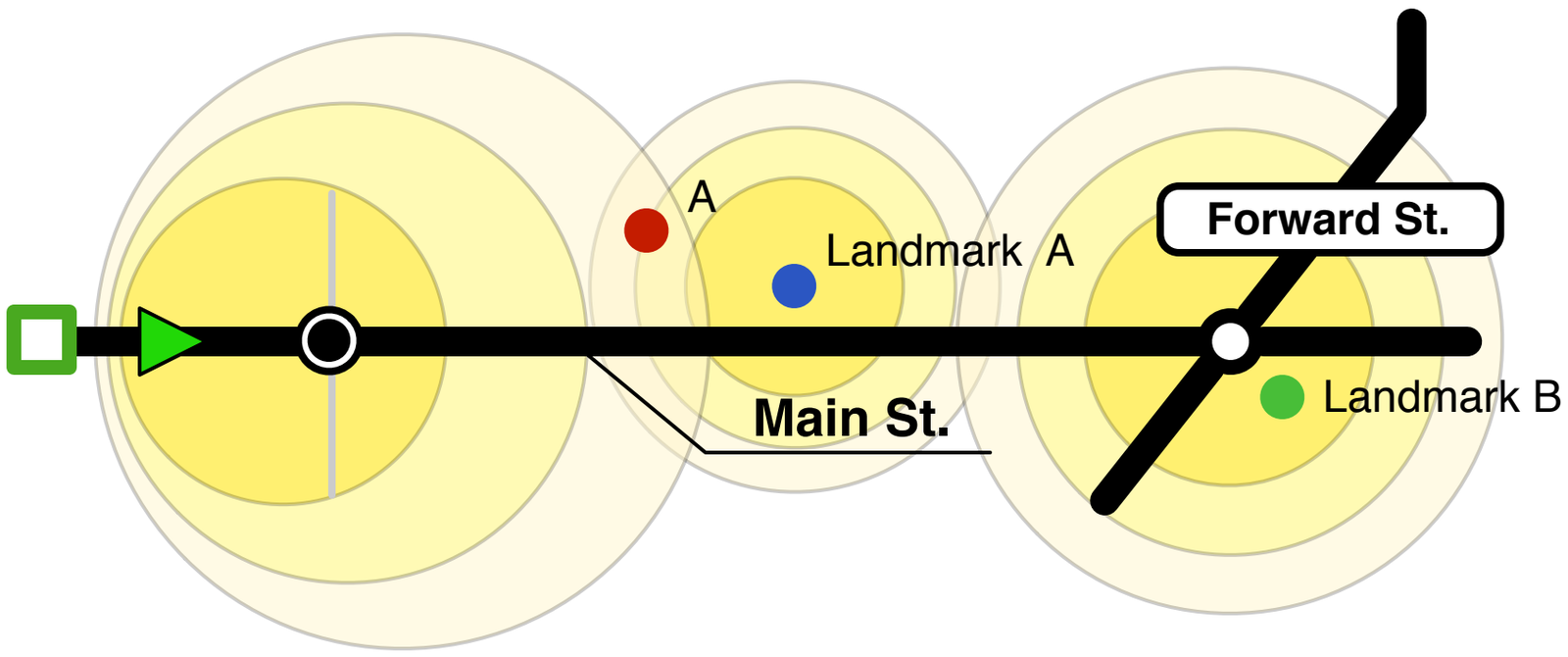
Scoring Renditions

- To get scores...
  - **Communicative Score**
    - planning to perform a set of user study similar to prior visual search study.
    - to create a more generalizable theory, more detailed feature analysis will be needed.
  - **Importance Score**
    - will be established through a heuristic (e.g., use of distance between a rendition and a critical point)
    - importance score changes for being close to the given type of critical point (e.g., next turn, landmark, or current vehicle position)



Scoring Renditions

- Importance circles may also be overlapped each other to calculate a more delicate importance score for each rendition



Final Placement Tuning

- When the renditions placed on the display, we may experience unexpected overlapping or clutter of renditions.
- **Final Placement Tuning** intervene for possible conflicts in the process of allocating map renditions.

Final Placement Tuning

- Related work explores point-feature label placement (PFLP) (Christensen, Marks & Shieber 1992, 1994, 1995)
  - attempts to resolve overlapping issues when placing multiple labels on a 2d space.
  - only focuses on the placement of point-feature labels.
  - to be used with the MOVE system, various types of renditions must be taken into consideration.
  - need to determine if we can benefit from this work or extend this work.

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Evaluating the Final System

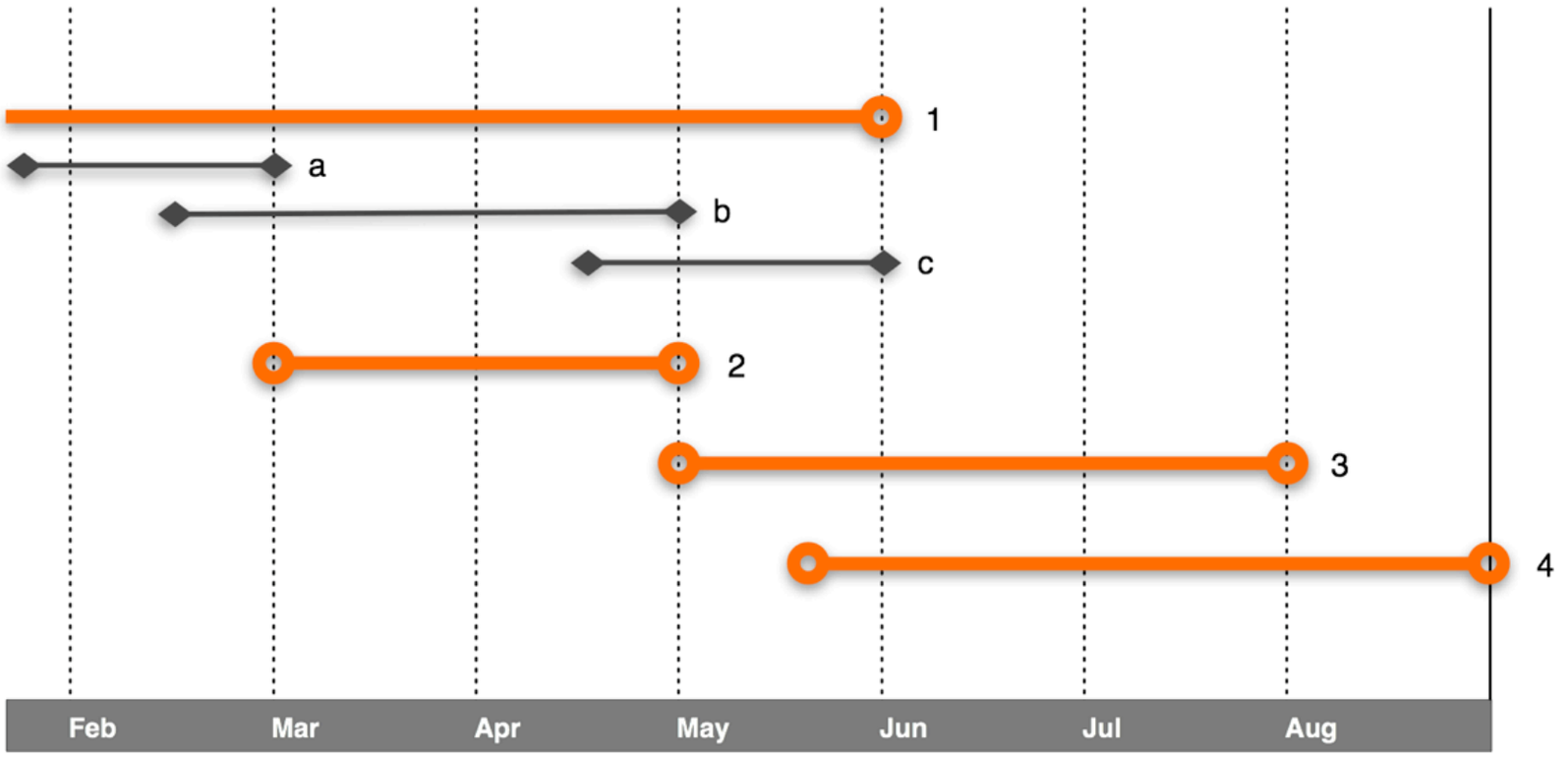
- We plan a set of evaluation study to verify whether our initial goal has been successfully achieved in the MOVE system.

1. Evaluation of algorithms used in the MOVE system.
   - a heuristic evaluation study with several interaction design experts
   - ask designers to generate route maps and compare them with the MOVE
2. Comparison to the current in-vehicle navigation systems.
   - dual task study in a simulated driving context
   - navigational performance and safety measures (similar to our feasibility study)

Contributions

- This work will contribute a method to present situationally appropriate information.
- To demonstrate the purpose, this work will contribute a design of the in-vehicle navigation system that demands less attention while driving.

Schedule



1. Implementation
- a. Road Layout
- b. Rendition Selection
- c. Final Placement Tuning

2. Scoring Study

3. Evaluation

4. Writing

Questions?

Joonhwan Lee <joonhwan@cs.cmu.edu>

Supplementary

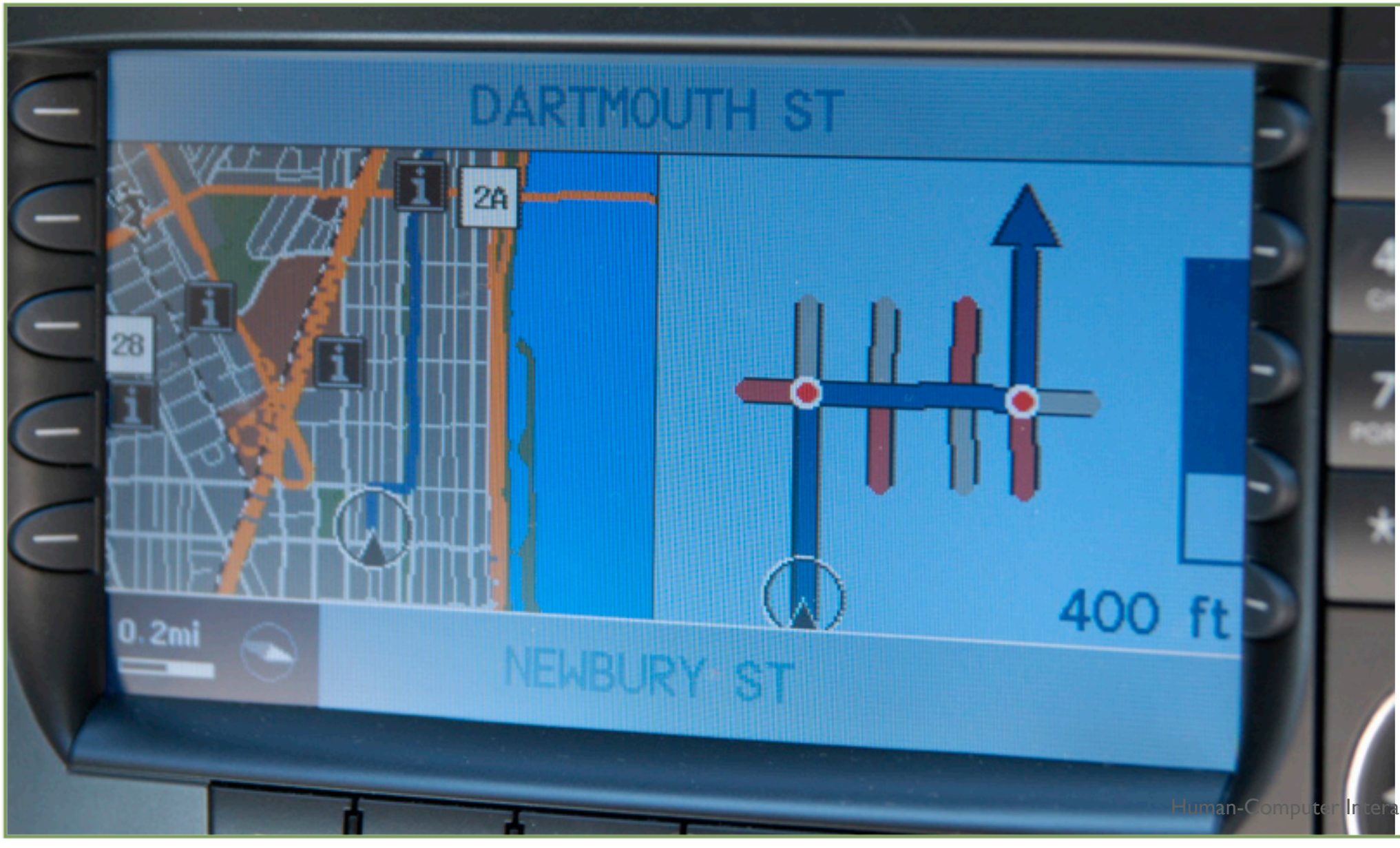
Implication of Cursor

- Reading the static map - need 2 tasks
  - Searching for context
  - Finding needed information
- Reading MOVE w/o cursor
  - Zooming into the context helped the participant to reduce search time

GPS Navigation Examples

GPS Navigation Examples

GPS Navigation Examples



Screen Size

- After market product
  - relatively small screen display
  - 3.5” ~ 4.5” physical size
  - 320 x 240 (QVGA) ~ 640 x 480 (VGA)
- Installed with vehicle
  - large display
  - most high-resolution is 1440 x 234, 6.5”
- High resolution is important for legibility, details.
- Big physical size is important for available amount of information.