Rendering Effective Route Maps

Improving Usability Through Generalization

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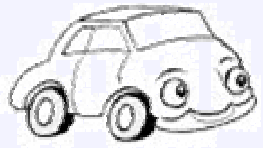
- Introduction
- Route Map – Informations
- Generalization
- LineDrive – The System
- Layout Search & Scoring
- Evaluation
- Conclusion

Introduction

Route Map

- Graphic communication
- Information overload
- Essential / extraneous informations
- Overlap & clutter

A



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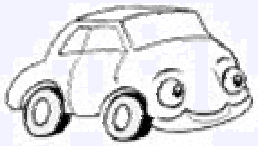

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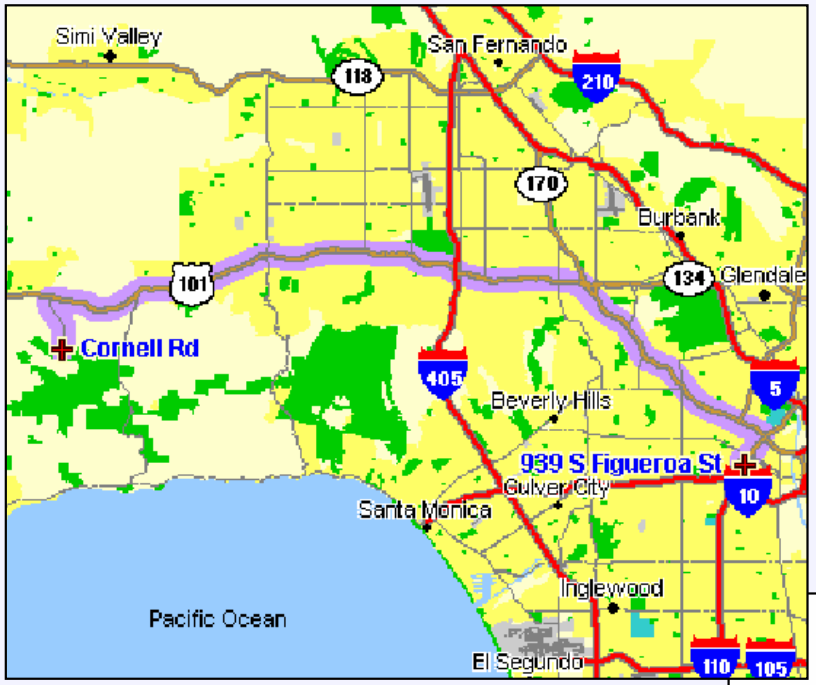
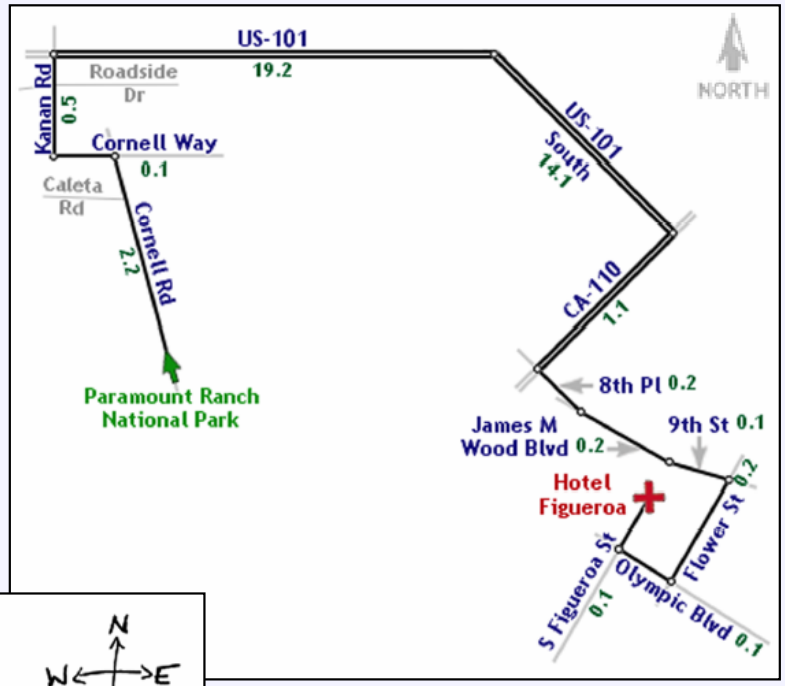
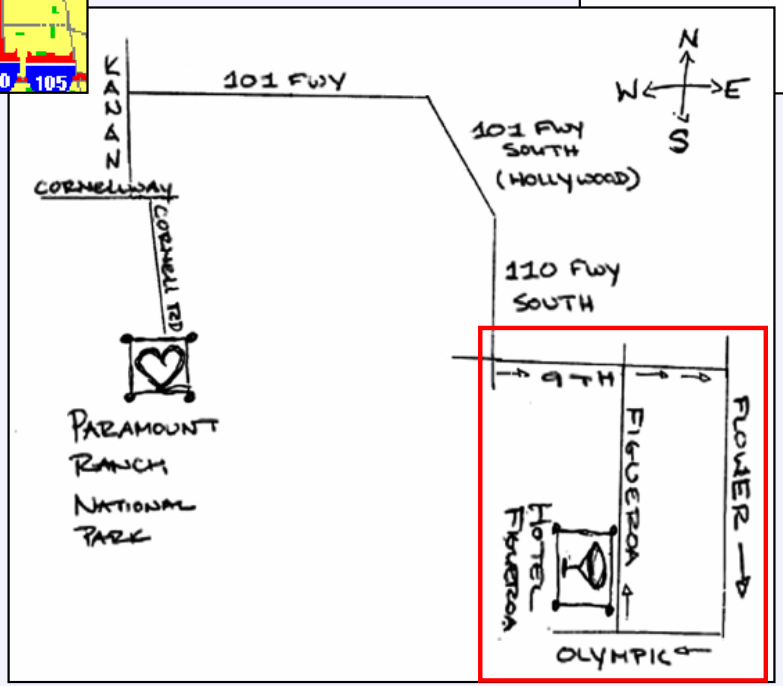


Generalization:
Distortion
Simplification
Abstraction



Constant scale factor

Cluttered with irrelevant informations



Emphasize most important informations

Route Map – Informations

- Verbal route directions:
  Communication of turn directions
  and road names

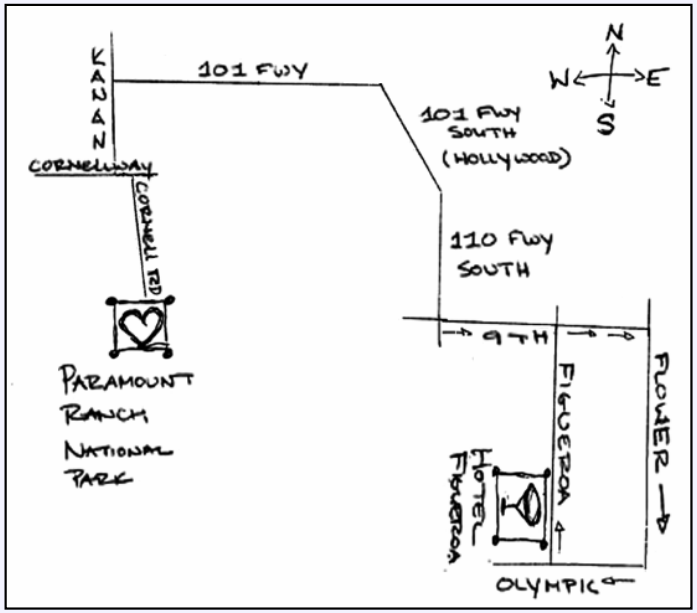
- Cognitive psychology:
  People think of routes as a sequence
  of turns

Route Map – Informations

- Cross-streets, local landmarks and distances for verification, but not essential for navigation

  → Additional information only when not interfere

- Hand-drawn maps maintain a similar structure



Generalization

Why Usability in Route Maps?

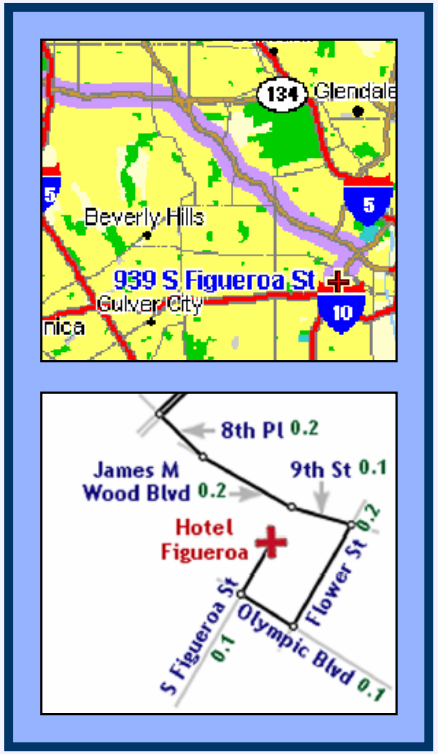
Often, navigators are also drivers

Attention is divided between many tasks

→ Information in a clear, easy-to-read manner
Convenient form-factor to carry and manipulate

Length Generalization

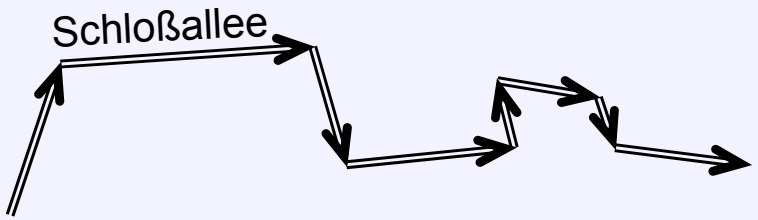
- For visibility, enlarge shorter roads and shorten longer roads in a controlled manner
- To fit in a conveniently sized image
- Shorter roads remain perceptually shorter than longer roads

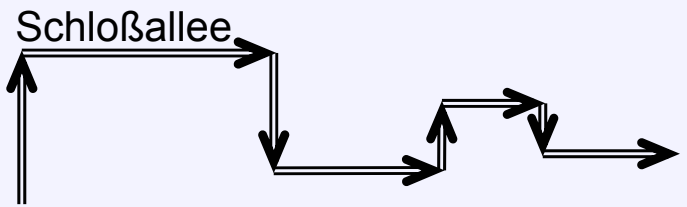


→ All roads and turning points are visible

Angle Generalization

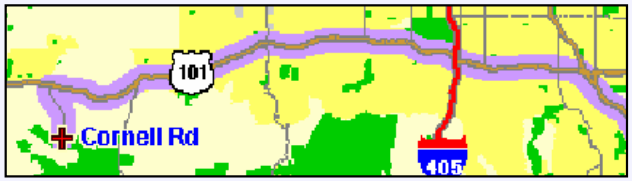
- Reorienting requires knowing only the turn direction, not the exact turning angle
- More Space for labeling clearly and length generalization
- Alignment with axes for cleaner looking



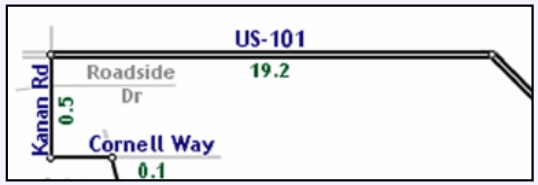


Shape Generalization

- Knowing the exact shape of a road is usually not important



- Removes extraneous information, emphasizes turning points



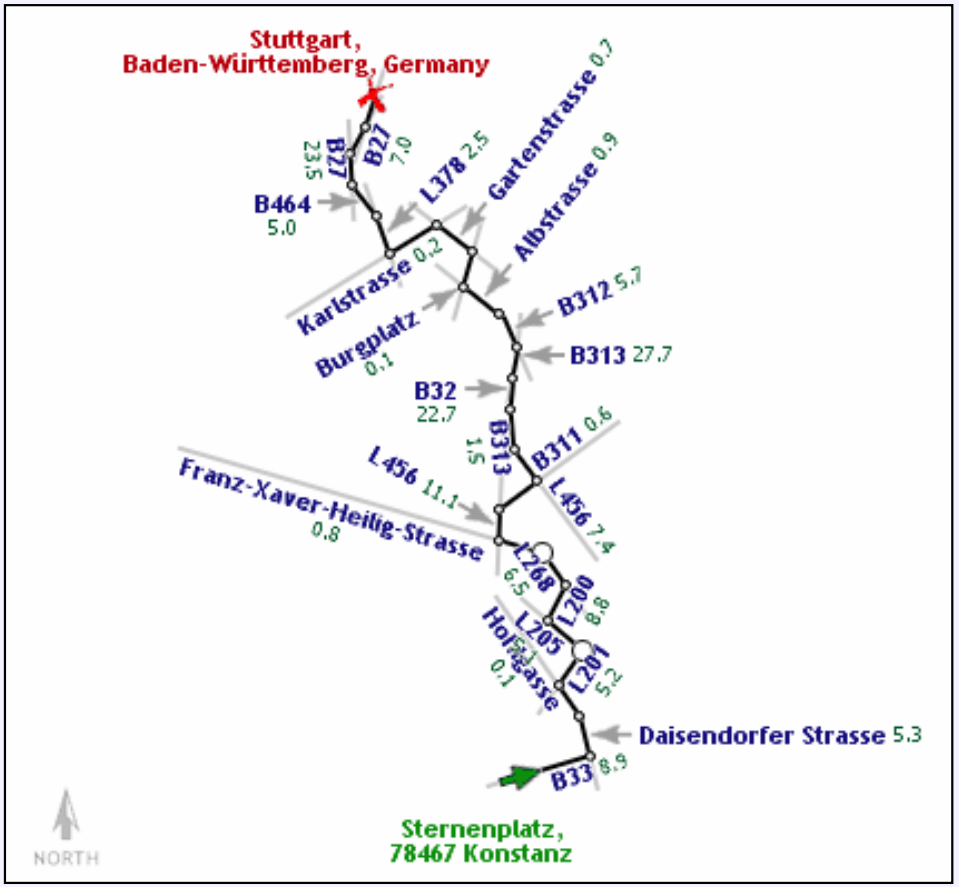
- Easier to percept roads as separate entities

- Easier to label clearly

LineDrive – The System

- Designs route maps in real-time
- Use generalization techniques commonly found in hand-drawn maps
- Gets sequence of roads
- Five independent stages

http://www.mapblast.com



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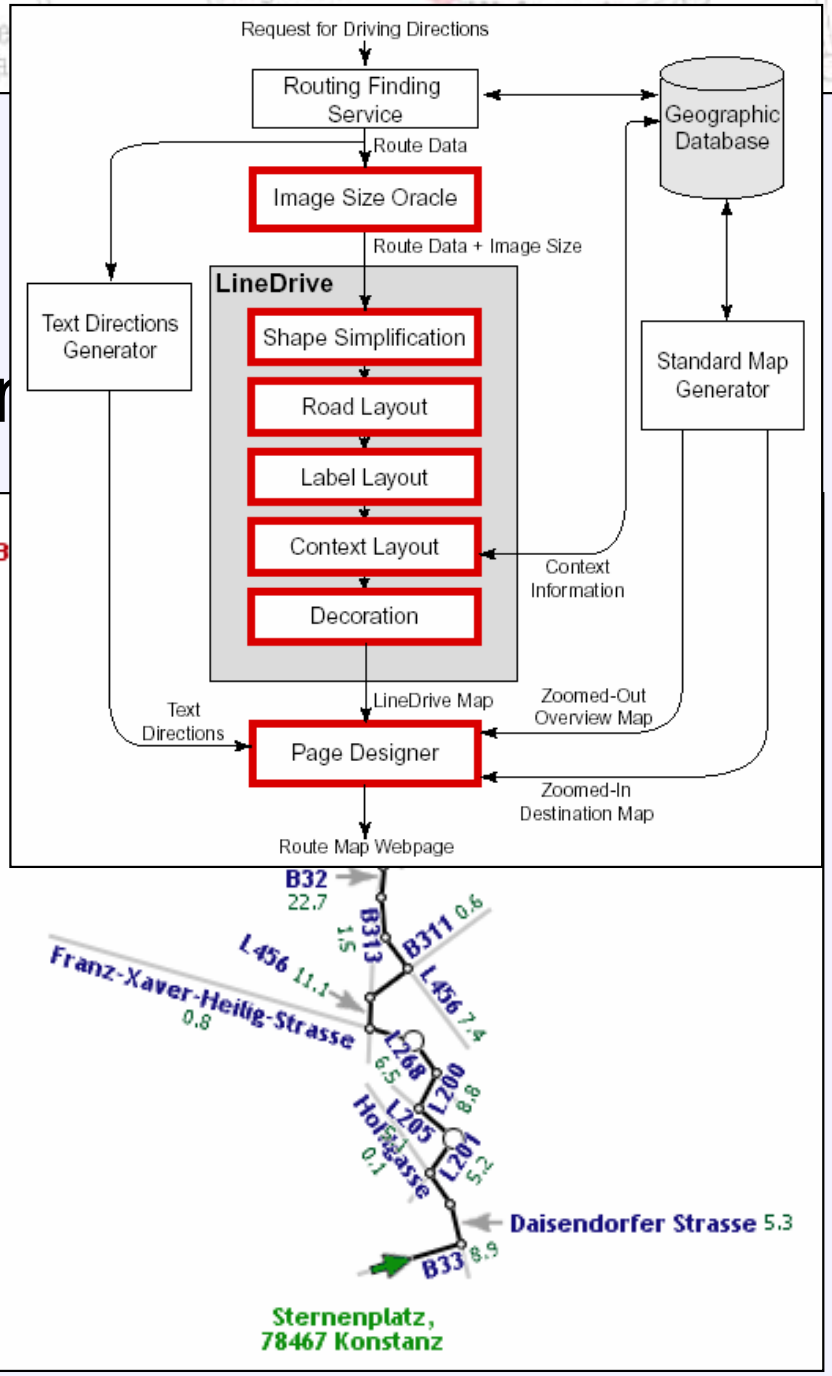
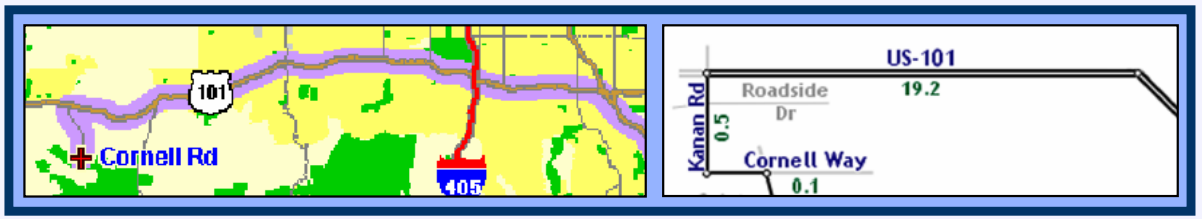


Shape Simplification

- Reduce number of segments so that the overall shape of routes remain
- Curve smoothing, interpolation, simplification
- Remove all removable shape points
- Remove highway ramps depending on length



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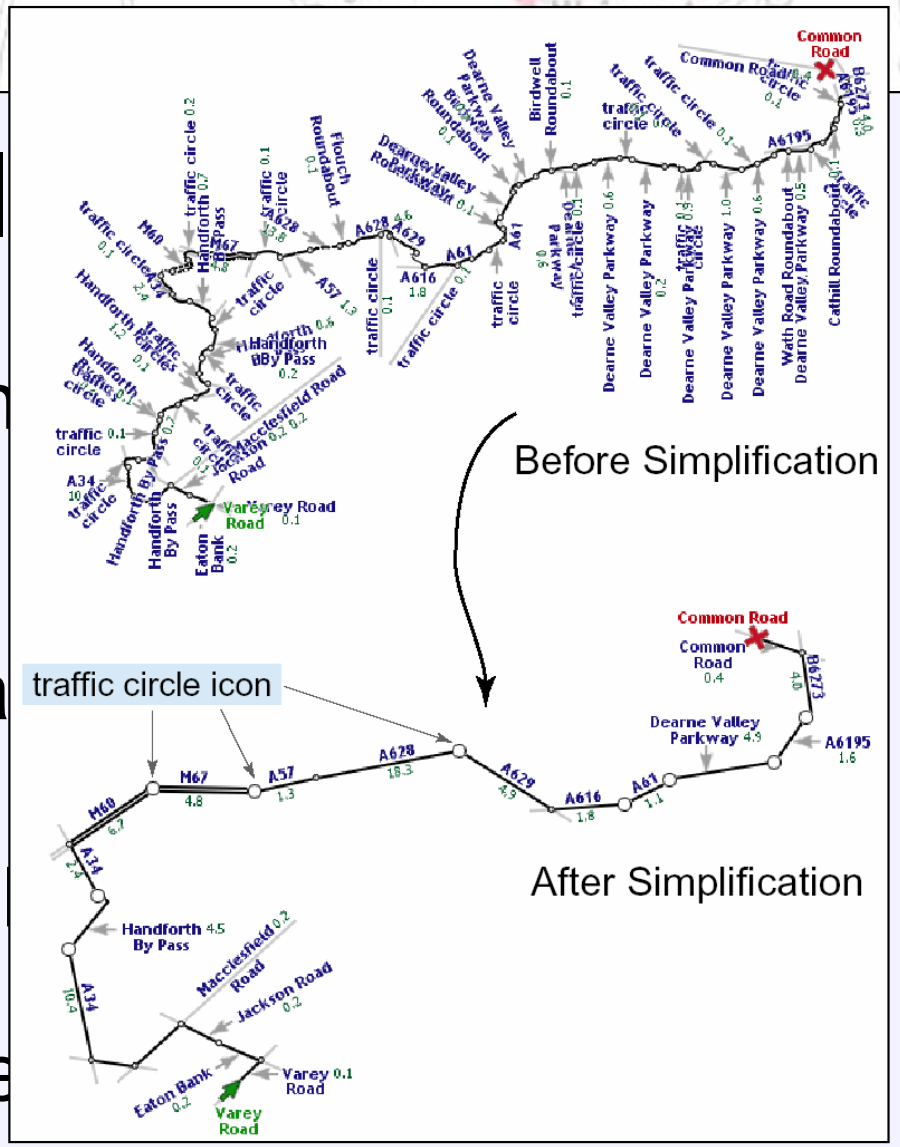
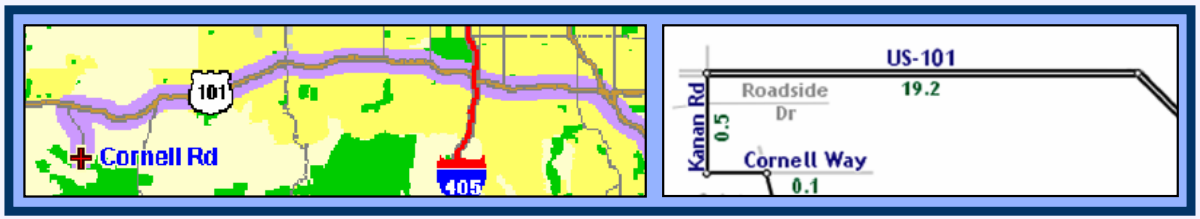


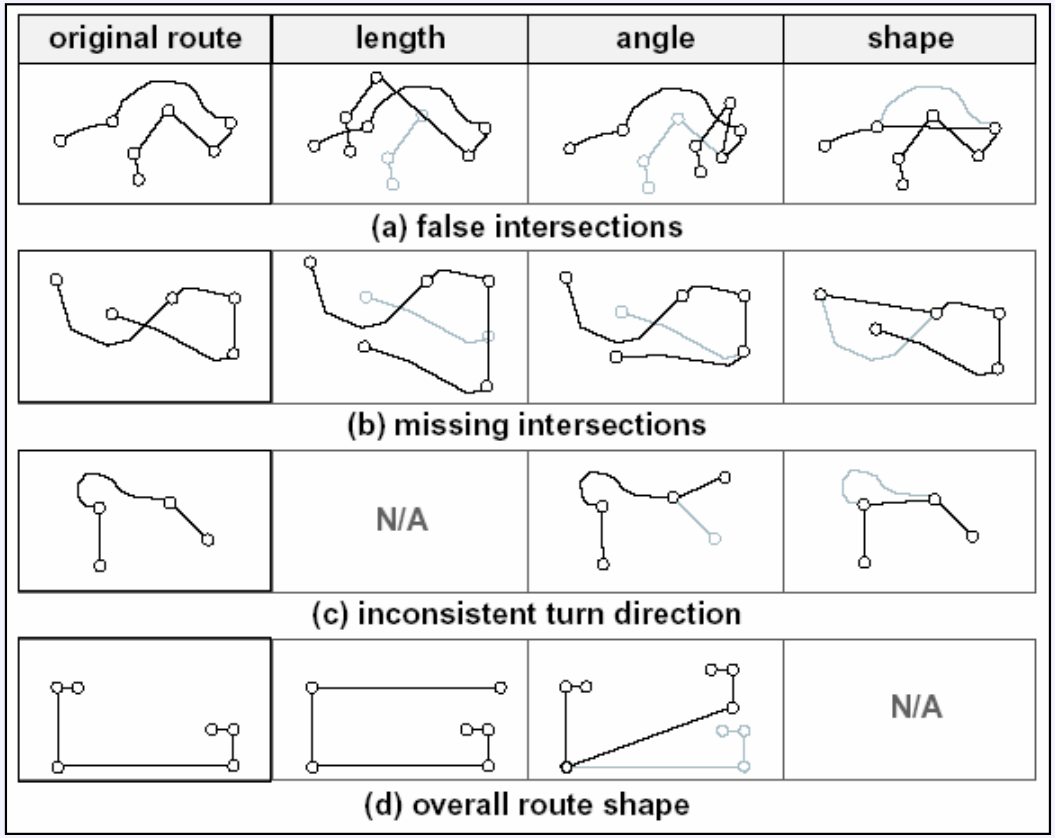


Shape Simplification

Undesirable effects:

- False intersections
- Missing intersections
- Inconsistent turn directions
- Overall route shape

→ Three removal tests

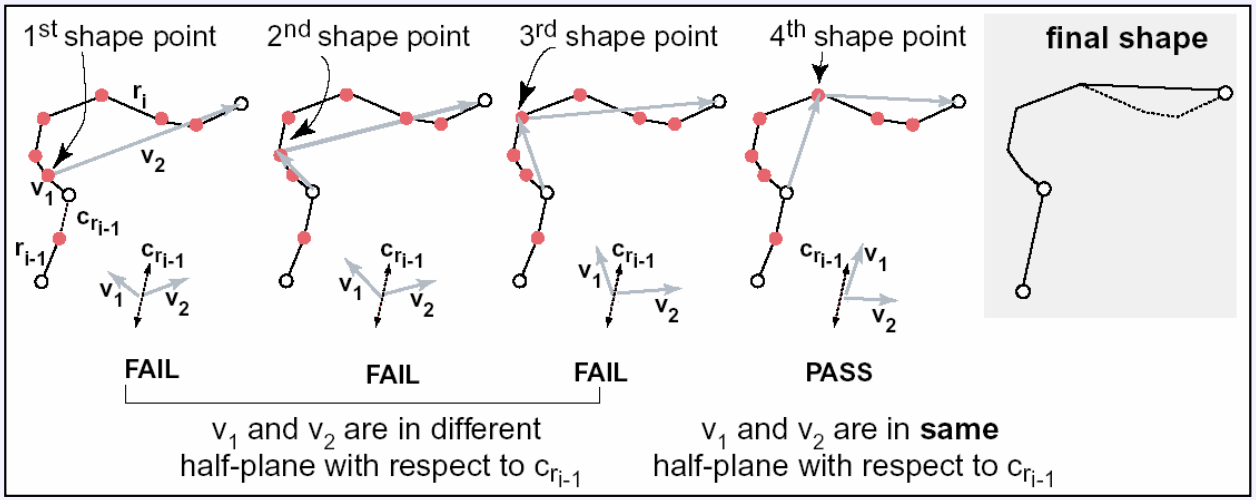


Shape Simplification

1. Mark start & end point and true intersection points as unremovable

2. Remove shape point only, if that doesn't create a new intersection

3. Remove only, if v_1 and v_2 are in same half-pane



Layout Search

- Search for an optimal layout over a space of possible layouts
- ScoreLayout(), quality of layout (evaluation criteria)
- PerturbLayout(), manipulates a given layout to a new Layout within the search space
- Decreasing probability of accepting bad moves (T--)

```
procedure SimAnneal()
1   InitializeLayout()
2   E ← ScoreLayout()
3   while(! termination condition)
4      PerturbLayout()
5      newE ← ScoreLayout()
6      if ((newE > E) and (Random() < (1.0 − e^(−ΔE/T))))
7         RevertLayout()
9      else
10        E ← newE
11     Decrease(T)
```

Road Layout

Determine length & orientation

→ all roads are visible, map fits within pre-specified size, preserve overall shape

1. Scale to viewport

2. For all roads < L_{min}:
   rLength = L_{min},

   Scale to viewport

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Road Layout

3. Perturb:
   scale random road by random factor (± 20%)
   change angle between ± 5 degree
   Scale to viewport

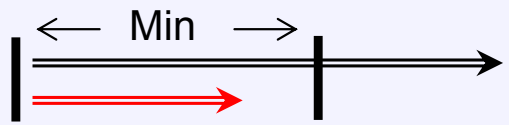
Align roads with angles < 15 degrees with the viewport axes to this axis:

→decreases visual complexity,
better for anti-aliasing (PDA)

Length & Orientation

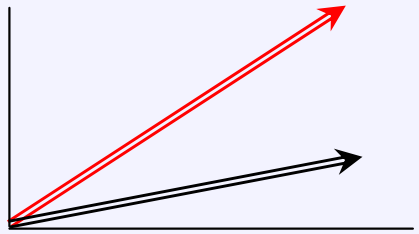
- Penalize any road $r_i < L_{min}$:

$$score(r_i) = ((l(r_i)-L_{min})/L_{min})^2 * W_{small}$$



- Penalize each road proportional to the difference between its current and its original orientation

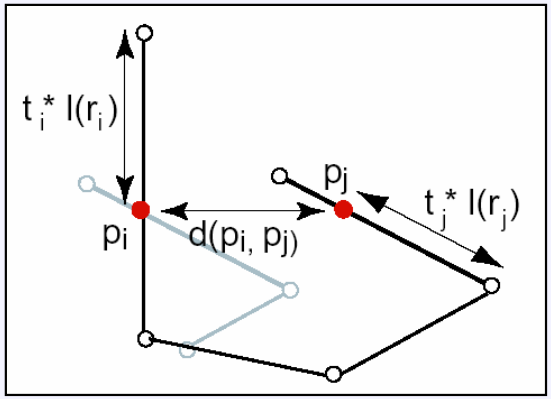
$$score(r_i) = |\alpha_{curr} - \alpha_{orig}| * W_{orient}$$



Intersections

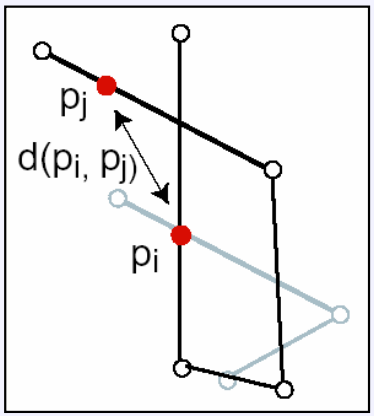
- Missing intersection

$$score(r_i, r_k) = d * W_{missing}$$



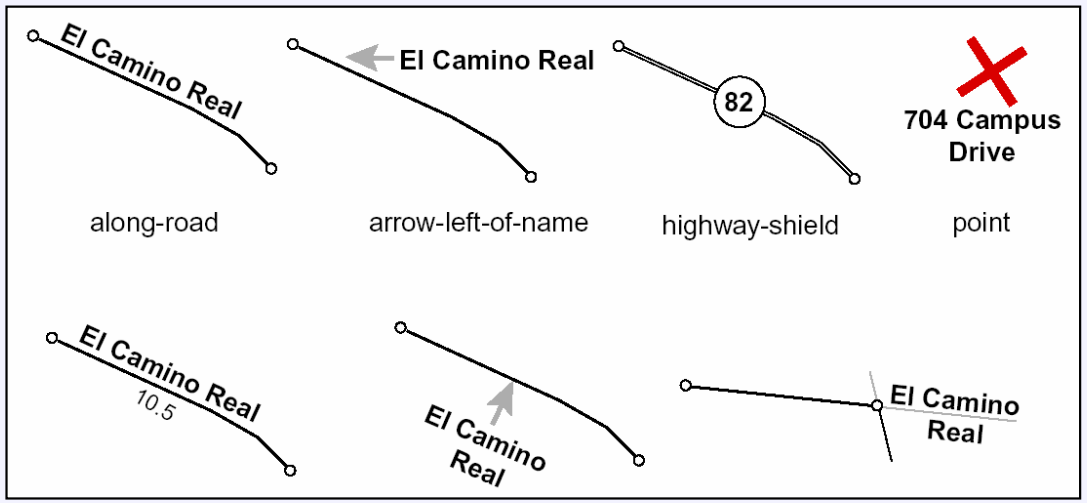
- Misplaced intersection

$$score(r_i, r_k) = d * W_{misplaced}$$



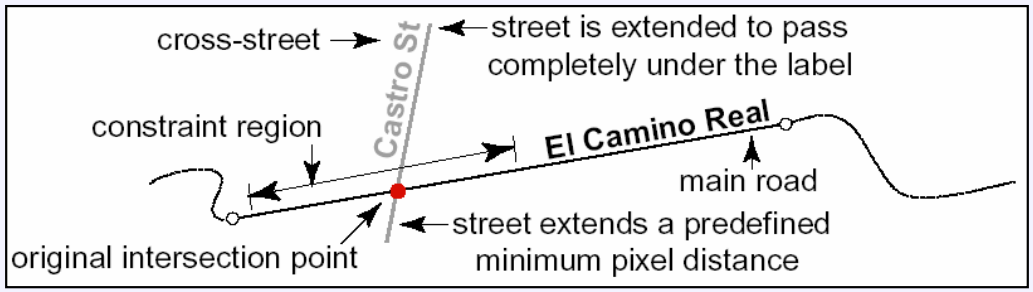
Label Layout

1. List of possible labeling styles for each object
2. Rank labeling styles
3. Create initial layout with highest ranked styles
4. If no conflict is possible, fix it.
5. Perturb only not fixed labels
6. Score by proximity, intersection, rank



Context Layout

- Linear features (cross-streets)
- Point landmarks (buildings, highway exit signs)
- Importance value increase towards turning points
- Constraint region for perturbation
- Score for deviation, intersections, normal road scoring, hidden



Decoration

Four types of graphic decoration to enhance usability:

- Extensions on the ends of each road
- Orientation arrow for overall navigation
- Bullets add each turning point
- Rendering style is set according to the type of road

Evaluation

- 7727 routes for PDA & 600x400
- 2242 users, feedback form on www.mapblast.com

Performance Statistics				(7727 routes)
	Web		PDA	
Median Time		0.7s		0.8s
Short Roads (< 10 pixels)	415	5.4%	430	5.6%
False Intersections	25	0.3%	23	0.3%
Missing Intersections	15	0.2%	14	0.2%
Label-Label Overlaps	37	0.5%	289	3.7%
Label-Road Intersections	901	11.7%	2096	27.1%

Evaluation

- Little detail outside main route
- Long distance trips require more context, most users require a road atlas for detailed context

User Feedback		(2242 responses)
Would you use LineDrive maps in the future?		
1246	55.6%	Yes, I would use them instead of standard driving directions.
976	43.5%	Yes, I would use them along with standard driving directions.
20	0.9%	No thanks, I'll stick with standard driving directions.
How would you rate this feature?		
1787	79.7%	It's a blast.
253	11.3%	Just fine.
202	9.0%	Needs some work ...

Conclusion

- Overall orientation is difficult (Distortion)
- Little detail outside main route
- GER: Town signs are very important
- Not dynamic

→ Evaluate on route!

→ Enhance usability

→ GOOD!!!

References

- Maneesh Agrawala, Chris Stolte, “A Design and Implementation for Effective Computer-Generated Route Maps”, Stanford University, AAAI Symposium, 2000.
- Maneesh Agrawala, Chris Stolte, “Rendering Effective Route Maps: Improving Usability Through Generalization”, Stanford University, SIGGRAPH 2001.
- Maneesh Agrawala, “Visualizing Route Maps”, Dissertation, Stanford University, 2001.
- http://www.mapblast.com