A GPS-based Bicycle Route Choice Model for San Francisco, California

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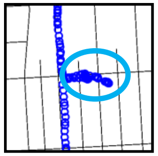
SAN FRANCISCO COUNTY TRANSPORTATION AUTHORITY

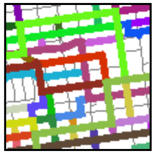
3rd Conference on Innovations in Travel Demand Modeling, Tempe, Arizona
May 10, 2010

Outline

- Introduction
- CycleTracks for iPhone & Android



- Data processing & participants



- Choice set generation

t-stat.	*p*-val.
−11.80	0.00
−12.15	0.00
−19.87	0.00
6.17	0.00

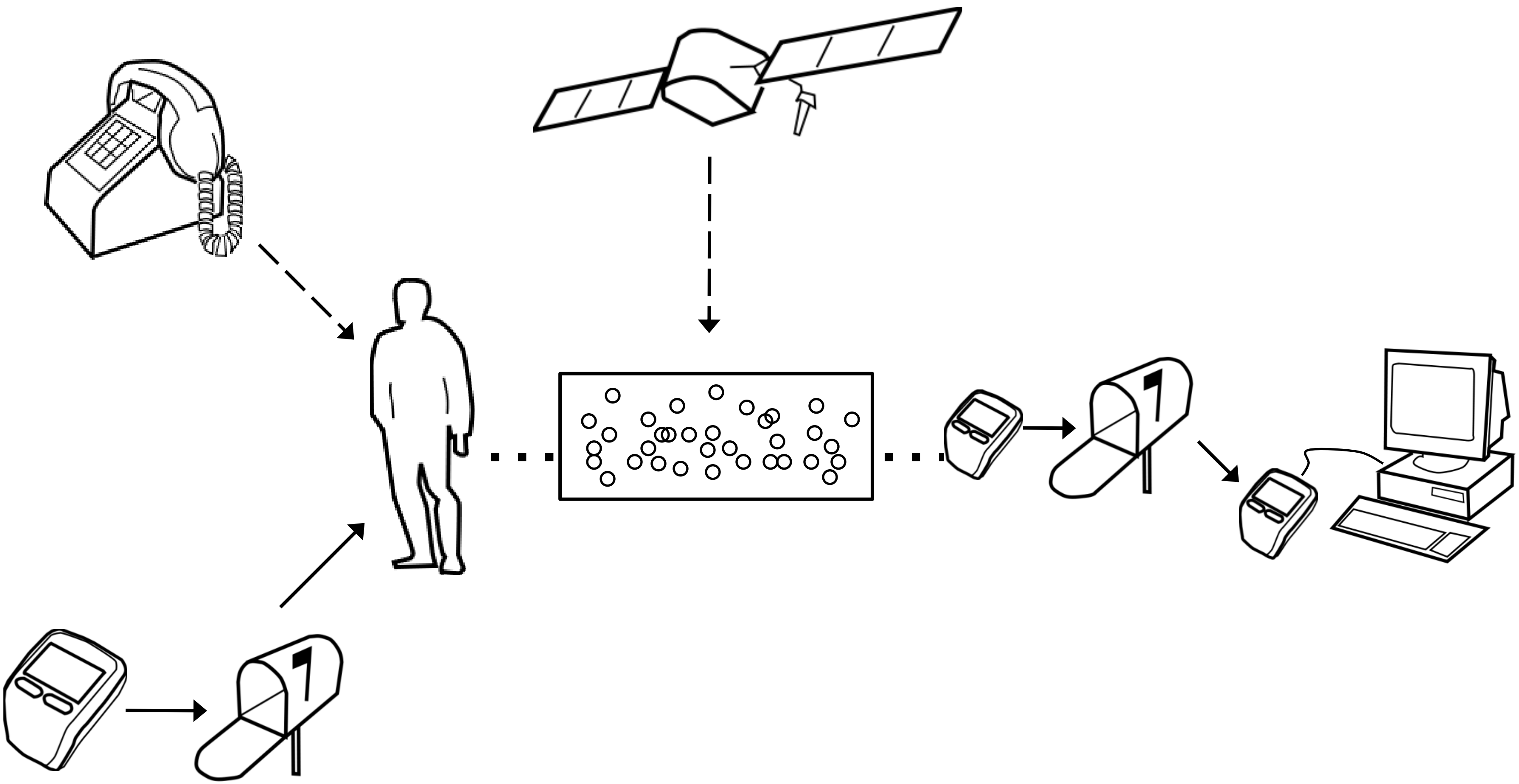
- Model estimation & validation

- Trip assignment & next steps

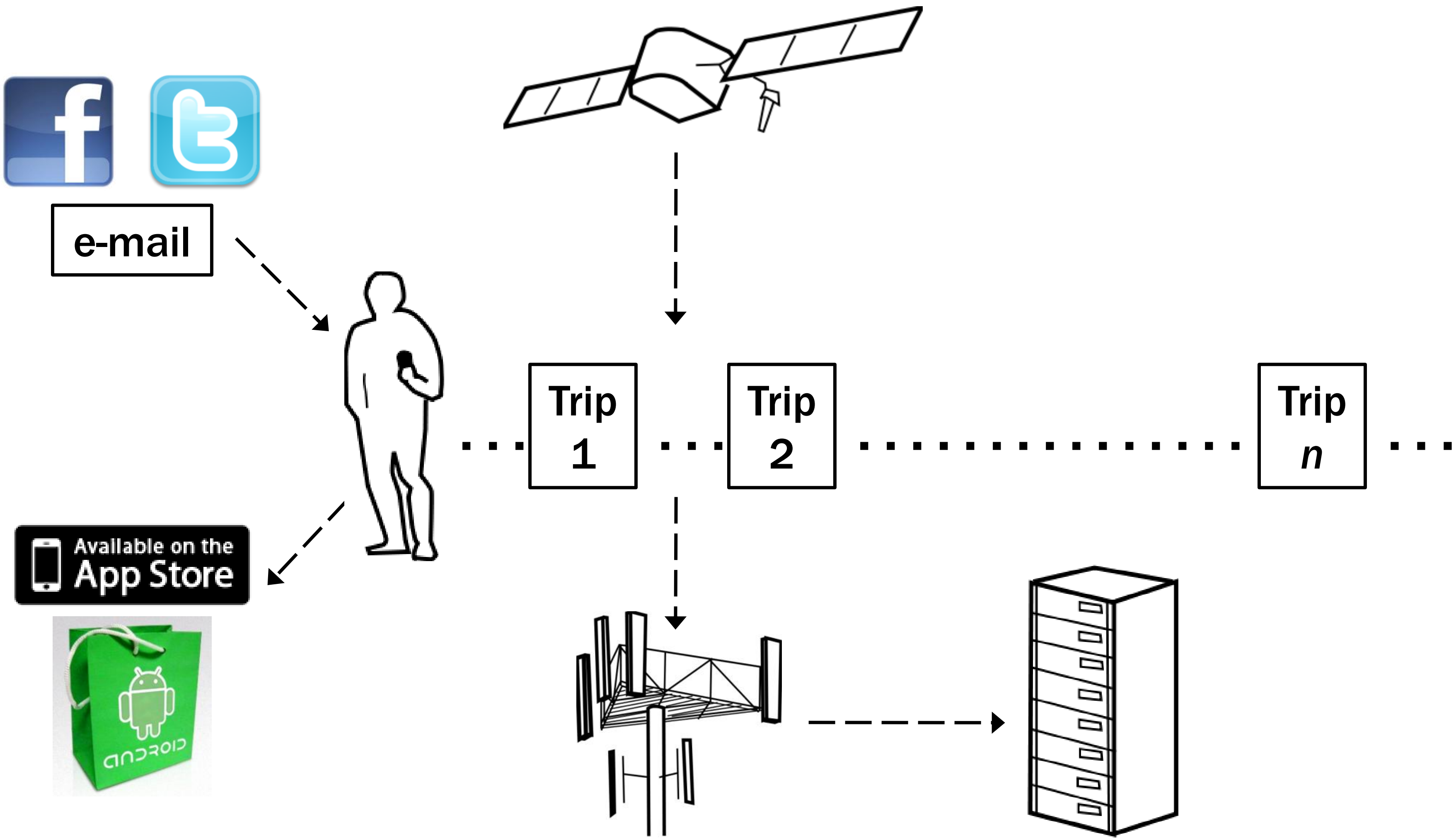
Why model bicycle route choice?

CycleTracks for iPhone & Android

Conventional GPS survey



CycleTracks smartphone app



Cycle Tracks

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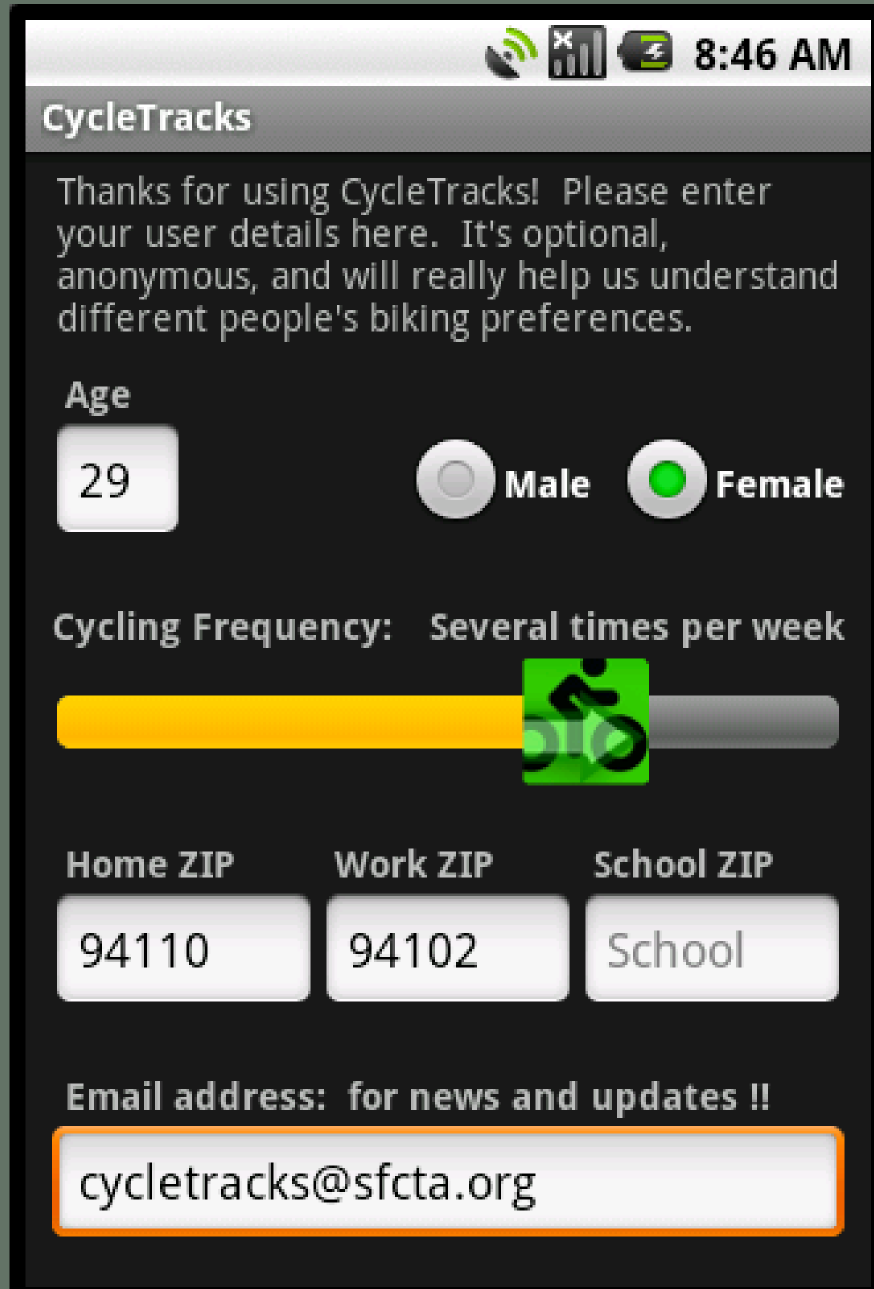
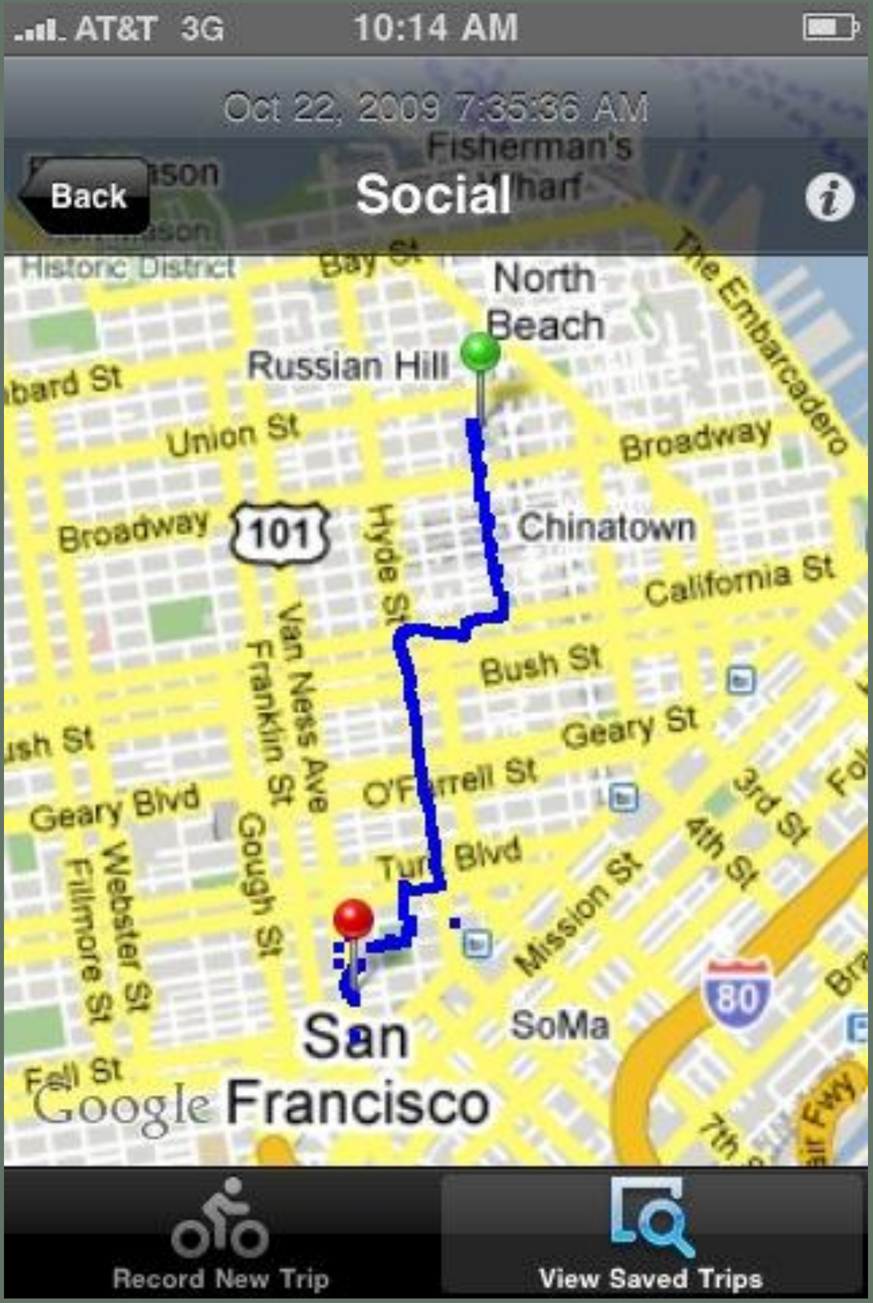

8:46 AM
CycleTracks
Thanks for using CycleTracks! Please enter your user details here. It's optional, anonymous, and will really help us understand different people's biking preferences.
Age
29
Male
Female
Cycling Frequency: Several times per week
Home ZIP
Work ZIP
School ZIP
94110
94102
School
Email address: for news and updates !!
cycletracks@sfcta.org


AT&T 3G
6:49 PM
Record
00:00:00
elapsed time
0.0 mi
estimated distance
0.0 mph
estimated speed
Start
Save
Lock
Webster St
War Memorial Opera House
Market St
9th St
8th St
Fell St
Oak St
Hayes Valley
Google
San Francisco
Instructions
Record
My Trips
Settings


AT&T 3G
10:14 AM
Back
Trip Purpose
Save
Work-Related
Exercise
Social
Shopping
Errand
The primary reason for this bike trip is going to or from a social activity (e.g. at a friend's house, the park, a restaurant, the movies).
Record New Trip
View Saved Trips


AT&T 3G
10:14 AM
Oct 22, 2009 7:35:36 AM
Back
Social
Fisherman's Wharf
Historic District
Bay St
North Beach
Russian Hill
The Embarcadero
Union St
Broadway
Chinatown
101
Hyde St
California St
Bush St
Van Ness Ave
Franklin St
Geary St
Geary Blvd
O'Farrell St
Webster St
Fillmore St
Gough St
Mission St
3rd St
4th St
80
SoMa
San Francisco
Fell St
Google
Record New Trip
View Saved Trips


AT&T 3G
10:13 AM
Edit
View Saved Trips
Shopping: 0m
Oct 27, 2009 10:12:56 AM
(recording in progress)
Social: 2806m
Oct 22, 2009 7:35:36 AM
(trip saved & uploaded)
Commute: 0m
Oct 21, 2009 9:38:14 AM
(trip saved & uploaded)
Commute: 2481m
Oct 21, 2009 7:59:27 AM
(trip saved & uploaded)
Record New Trip
View Saved Trips

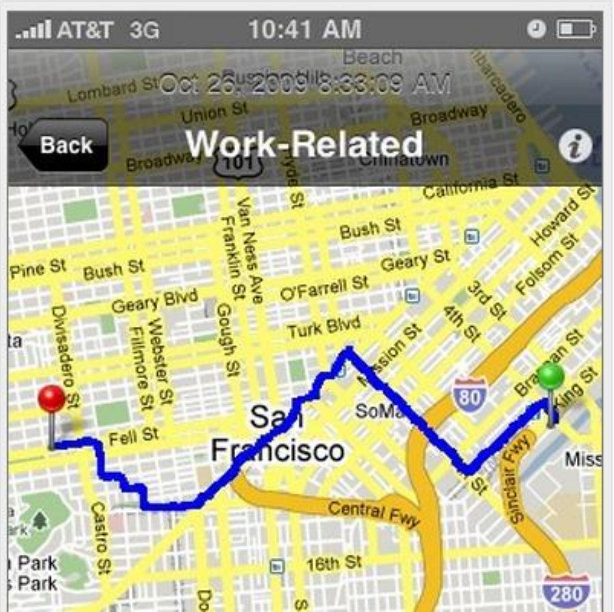
OK, it’s real pretty;
Now, how do we get users?

Thursday, November 12, 2009 31 Comments

SF Transportation Authority Launches iPhone App to Track Cyclists

by Matthew Roth on November 12, 2009

The San Francisco County Transportation Authority (TA), the city's congestion management agency responsible for modeling transportation and development patterns, has released its new bicycle route data application, Cycle Tracks, for iPhones and GPS-enabled iTunes players at the iTunes store. Like similar applications that give information such as speed and distance traveled, users of the TA app can map their bicycle ride, but the data they collect will be aggregated anonymously in the TA's server so that it can be applied to their SF-CHAMP modeling and travel forecasting tool.



"This app will help the cycling community help itself," TA Executive Director José Luis Moscovich said in a statement. "The data they log will contribute to better planning of bicycle facilities, and they'll also have a record of their personal cycling history. I'm sure it will be very popular."

Billy Charleton, Deputy Director for Technology Services at the TA, explained that SF-CHAMP doesn't currently have concise and reliable trip data for cyclists, but that they rely on static counts at various intersections conducted once or twice a year. Without understanding the entire length of a trip, nor the trip purpose, the agency is unable to analyze what cyclists prefer in terms of street characteristics, including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Cycle Tracks
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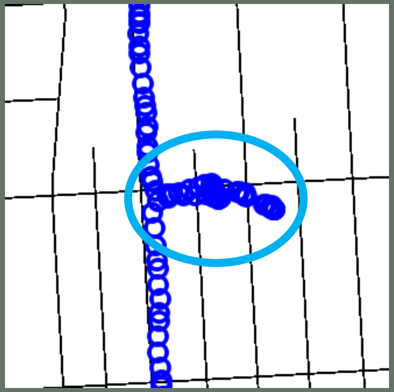
CycleTracks
Wall
Info
Discussions
Photos
Events
+
Write something...
Attach:
Share
Options
Tim Hickey
Wrong location spot
When I ride home at Howard and Spear, it sometimes puts my location in the bay, just north of the bay bridge. This seems to nullify my recording.
January 10 at 7:50pm · Participate
RECENT ACTIVITY
Jennifer Gile discussed Cycletracks on Android on the CycleTracks discussion board.
Dave Mangot discussed Cycletracks on Android on the CycleTracks discussion board.
Billy Charlton and Dave Mangot discussed Cycletracks on Android on the CycleTracks discussion board.
Dave Mangot
Cycletracks on Android
I tried recording two different trips on my Samsung Moment (cupcake) and in both cases, it said 0 miles. After that I discovered that after I hit Start Trip it says elapsed time 1 second, and that's the end. Never advances past one second. (and thus, my distance, etc...
See More
December 16, 2009 at 10:13am · Participate
Jeffrey Carl Faden
Message All Members
Promote Group with an Ad
Edit Group Settings
Edit Members
Invite People to Join
Create Group Event
Leave Group
Start using CycleTracks today!
Download from the App Store at http://bit.ly/CycleTracks or from the Android Market app on your phone.



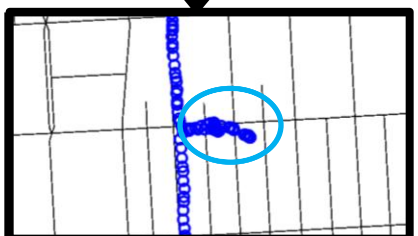
Data Processing & Participants

GPS post-processing (Schüssler & Axhausen 2009)

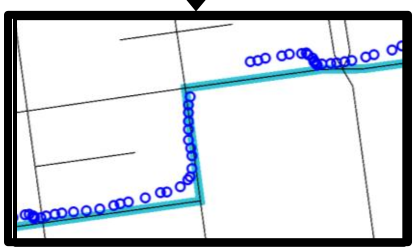
5,178 traces
497 users

$$\exp - \frac{(t - t_j)^2}{2\sigma^2}$$

Gaussian smoothing



Activity & mode detection

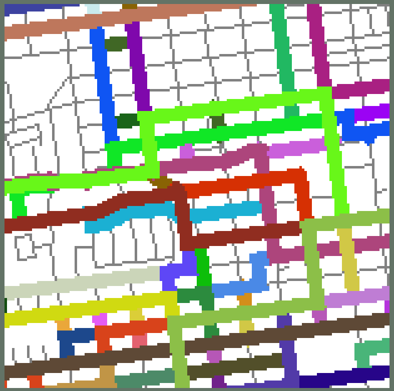


Map matching

3,034 bike stages
366 users

Participants

	CycleTracks (N=366)	BATS (N=153)	*z*-stat	*p*-value
Age				
Mean	34	33	1.1	0.31
Gender				
Female	21%	36%	–3.5	0.00
Cycling Frequency				
Daily	60%	N/A		
Several times per week	34%			
Several times per month	7%			
Less than once a month	0%			



Choice Set Generation

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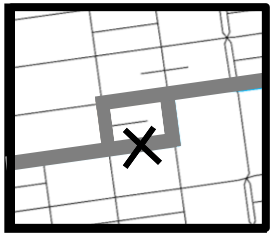
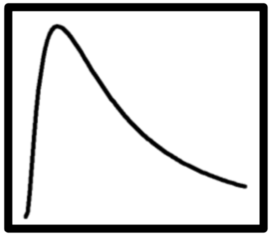
Existing methods

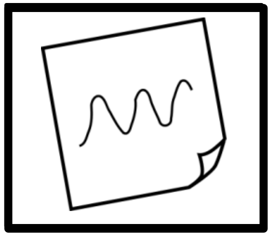
Only shortest path searches work in large networks



Link elimination
(*k* shortest paths)



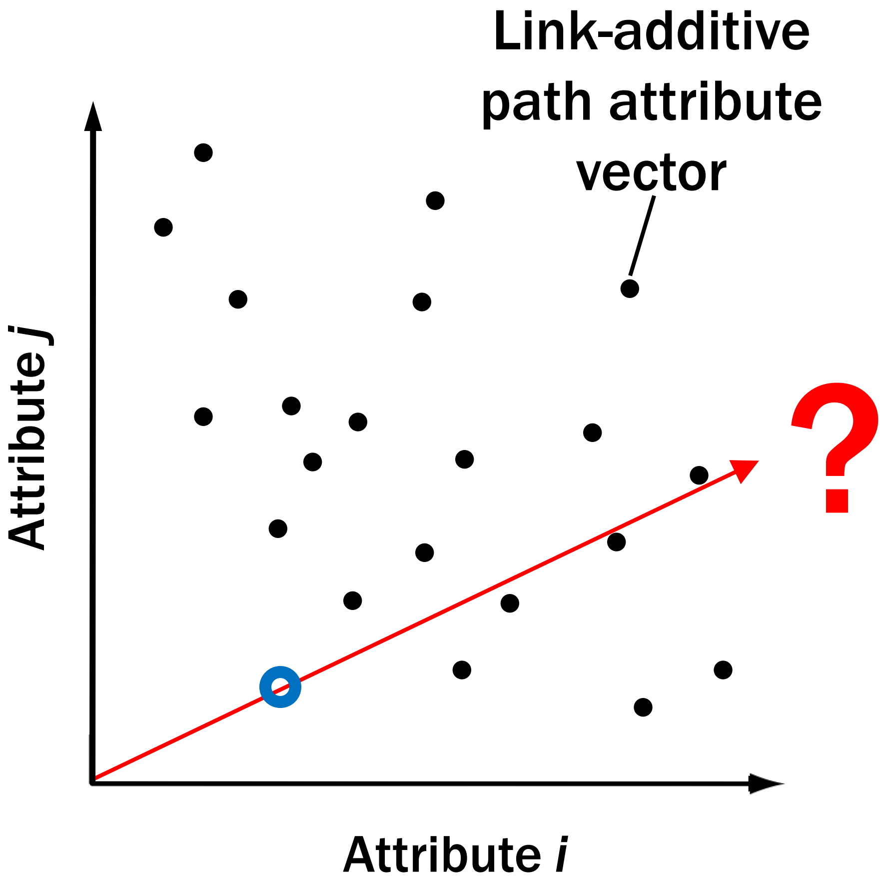
Stochastic
path search



Labeled
paths

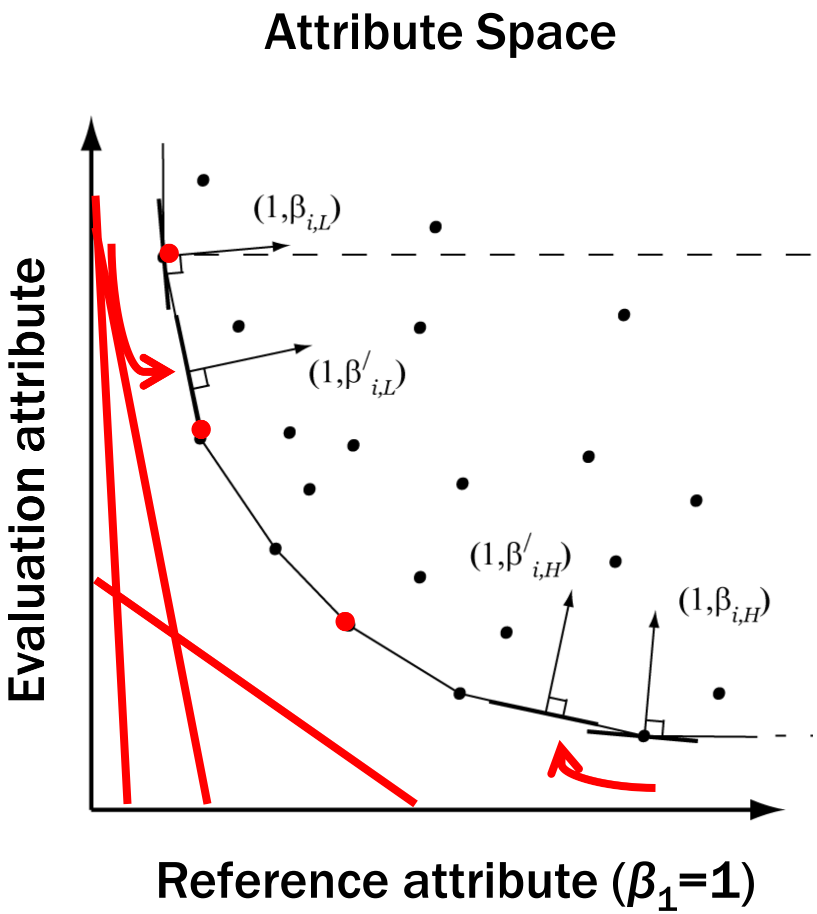
→ Doubly stochastic
(Bovy & Fiorenzo-Catalano 2007)

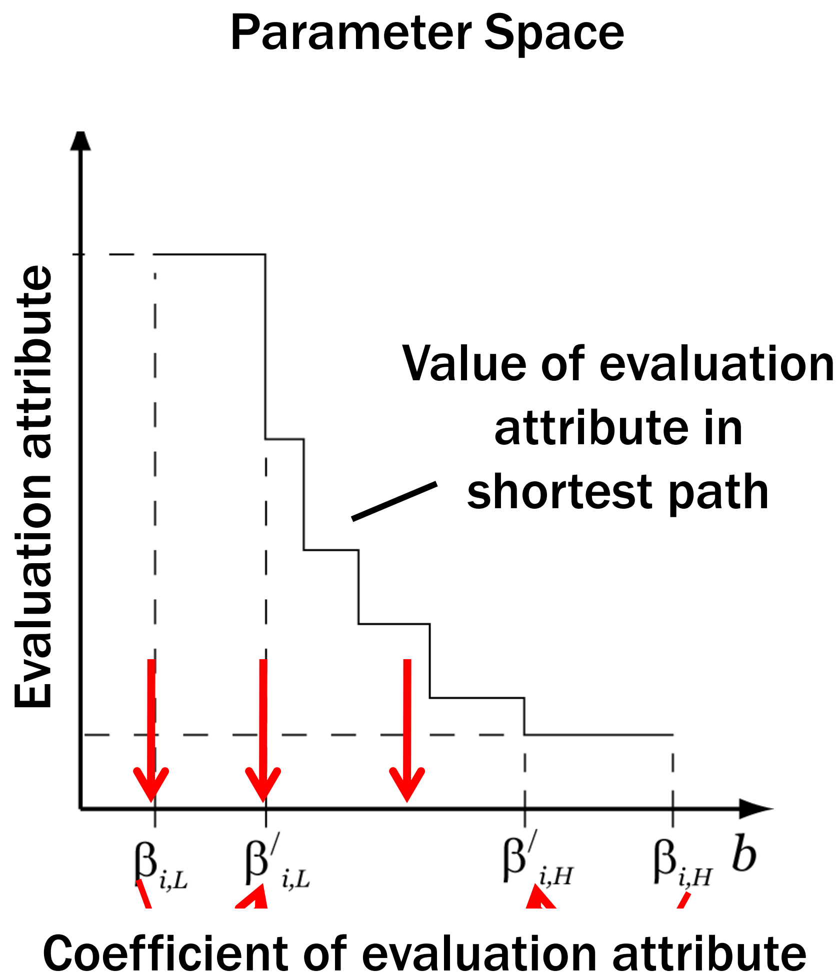
The doubly stochastic method



1. Select random coefficient vector
2. Calculate generalized cost for each link
3. Randomize link costs
4. Find shortest path

Extract unbiased priors from the network





Results of prior extraction

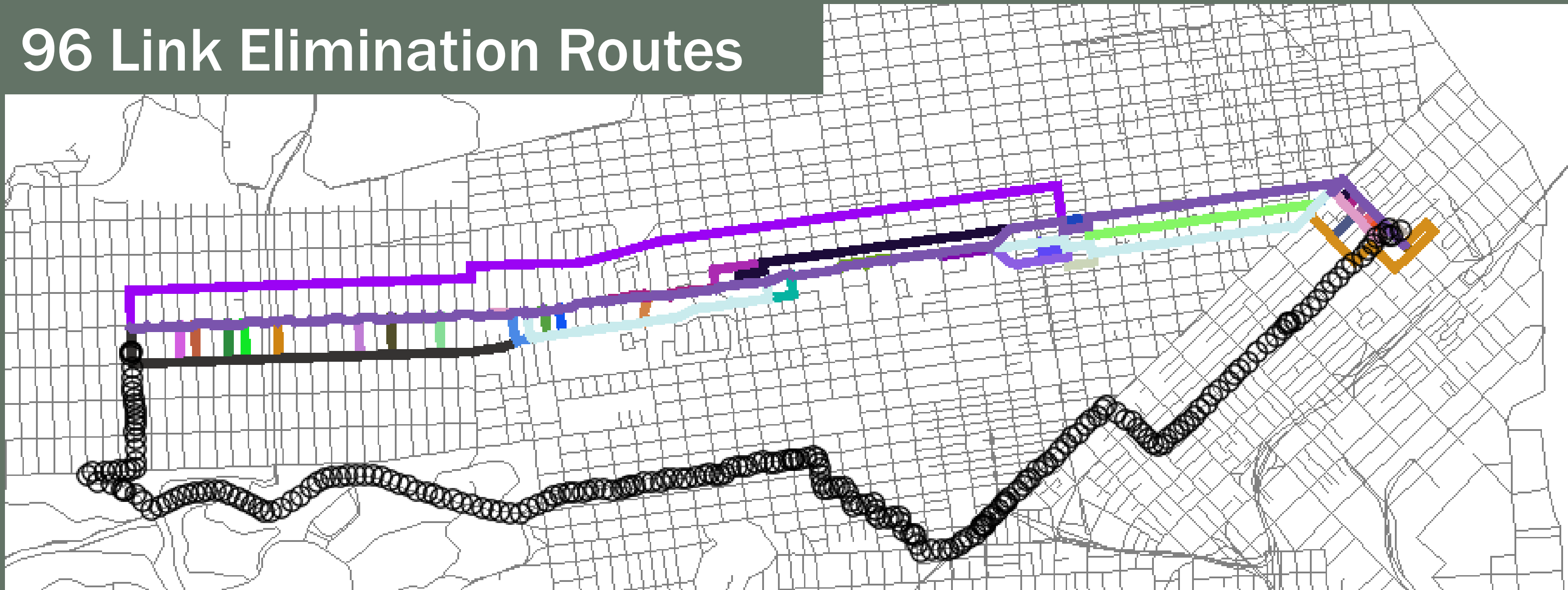
Significant in estimation

Attribute	Initial Interval $\beta_{i,L}$	Initial Interval $\beta_{i,H}$	Final Interval $\beta^*_{i,L}$	Final Interval $\beta^*_{i,H}$
Length (reference)	1.0	1.0	1.0	1.0
Length off bike paths	1.0×10^{-7}	1,000.	0.082	6.41
Length off bike lanes	1.0×10^{-7}	1,000.	0.075	5.29
Length off bike routes	1.0×10^{-7}	1,000.	0.098	10.8
Length × up-slope (ft/100 ft)	1.0×10^{-7}	1,000.	0.043	2.36
Length wrong way	1.0×10^{-7}	1,000.	0.031	0.49
Number of turns*	1.0×10^{-7}	1,000.	0.009	1.63
Length × daily traffic (1,000s)	1.0×10^{-7}	1,000.	0.010	9.51

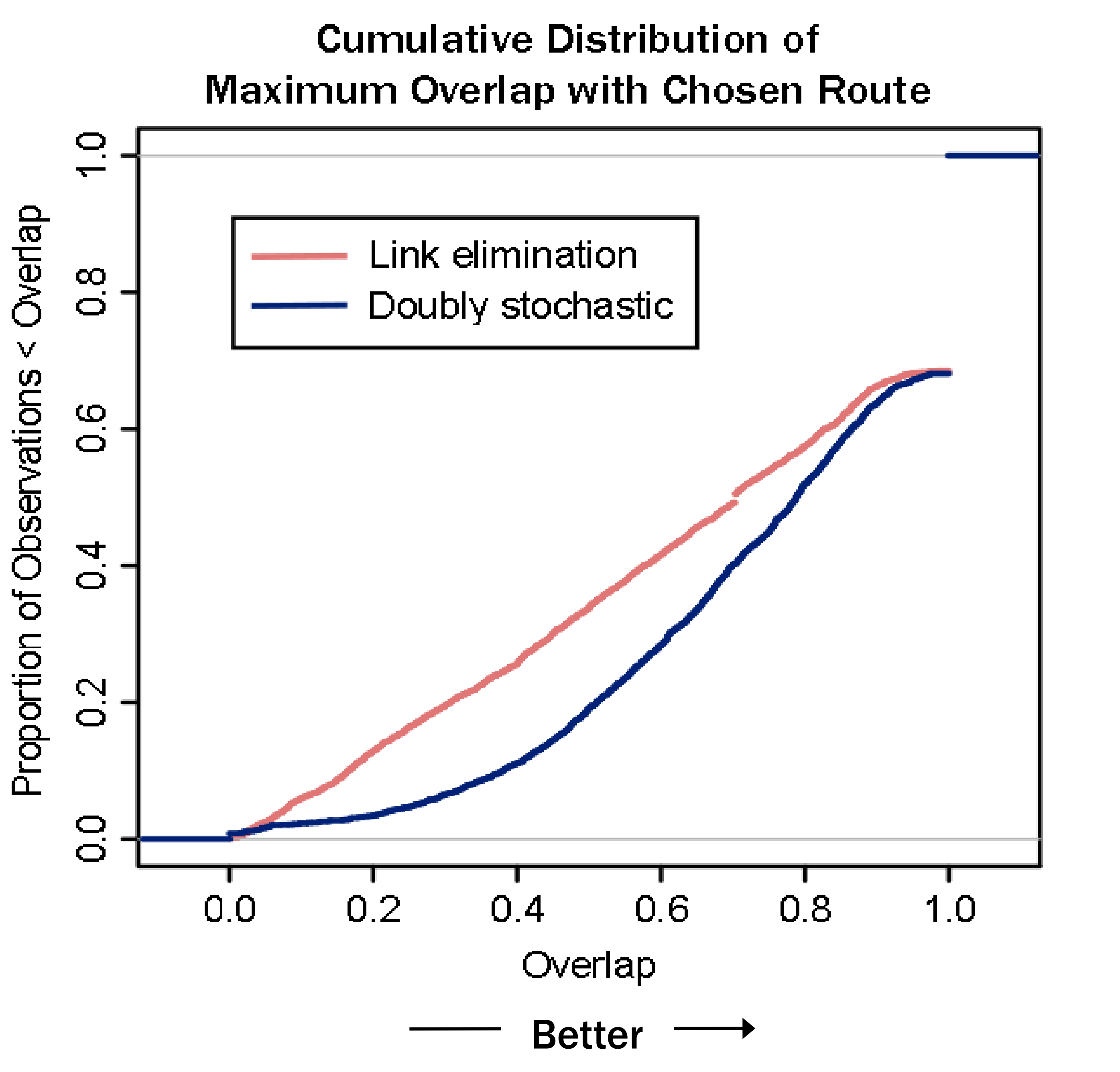
*Extracted with other coefficients at their medians

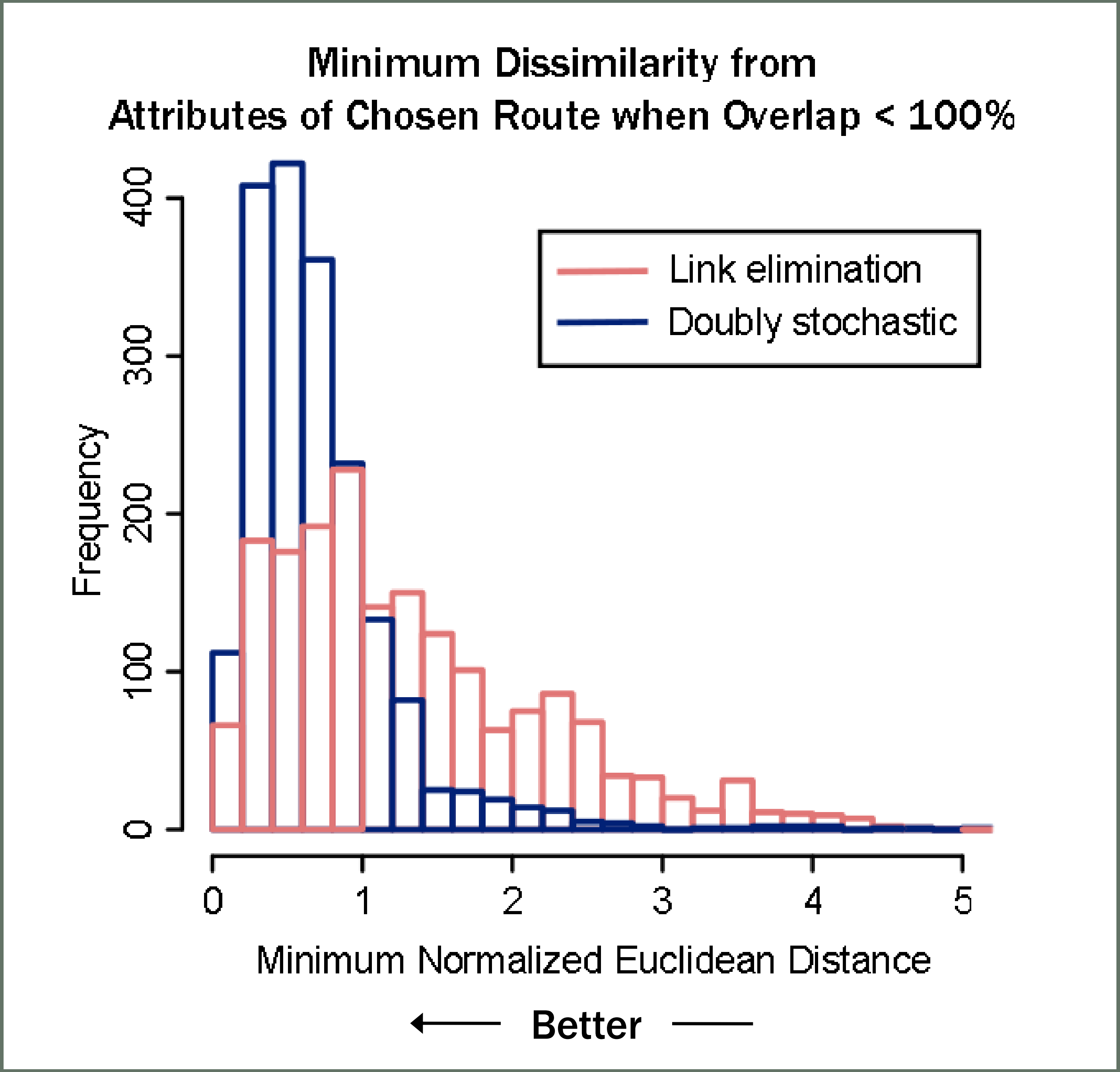
Retained for degree of freedom

96 Link Elimination Routes



96 Doubly Stochastic Routes


Cumulative Distribution of
Maximum Overlap with Chosen Route
Proportion of Observations < Overlap
0.0
0.2
0.4
0.6
0.8
1.0
Link elimination
Doubly stochastic
0.0
0.2
0.4
0.6
0.8
1.0
Overlap
Better



Minimum Dissimilarity from
Attributes of Chosen Route when Overlap < 100%
Link elimination
Doubly stochastic
Frequency
0
100
200
300
400
0
1
2
3
4
5
Minimum Normalized Euclidean Distance
Better

Benchmarking

Method	Doubly Stochastic	Link Elimination
No. parameters	32	–
No. link randomizations	3	–
No. unique routes	76 (avg.)	96
Search algorithm	Dijkstra	Euclidean A*
Computing time	**3 h 46 m**	**8 h 06 m**

2,678 observations, 4 CPUs, coded in Python

t-stat.	*p*-val.
−11.80	0.00
−12.15	0.00
−19.87	0.00
6.17	0.00

Model Estimation & Validation

Estimation results

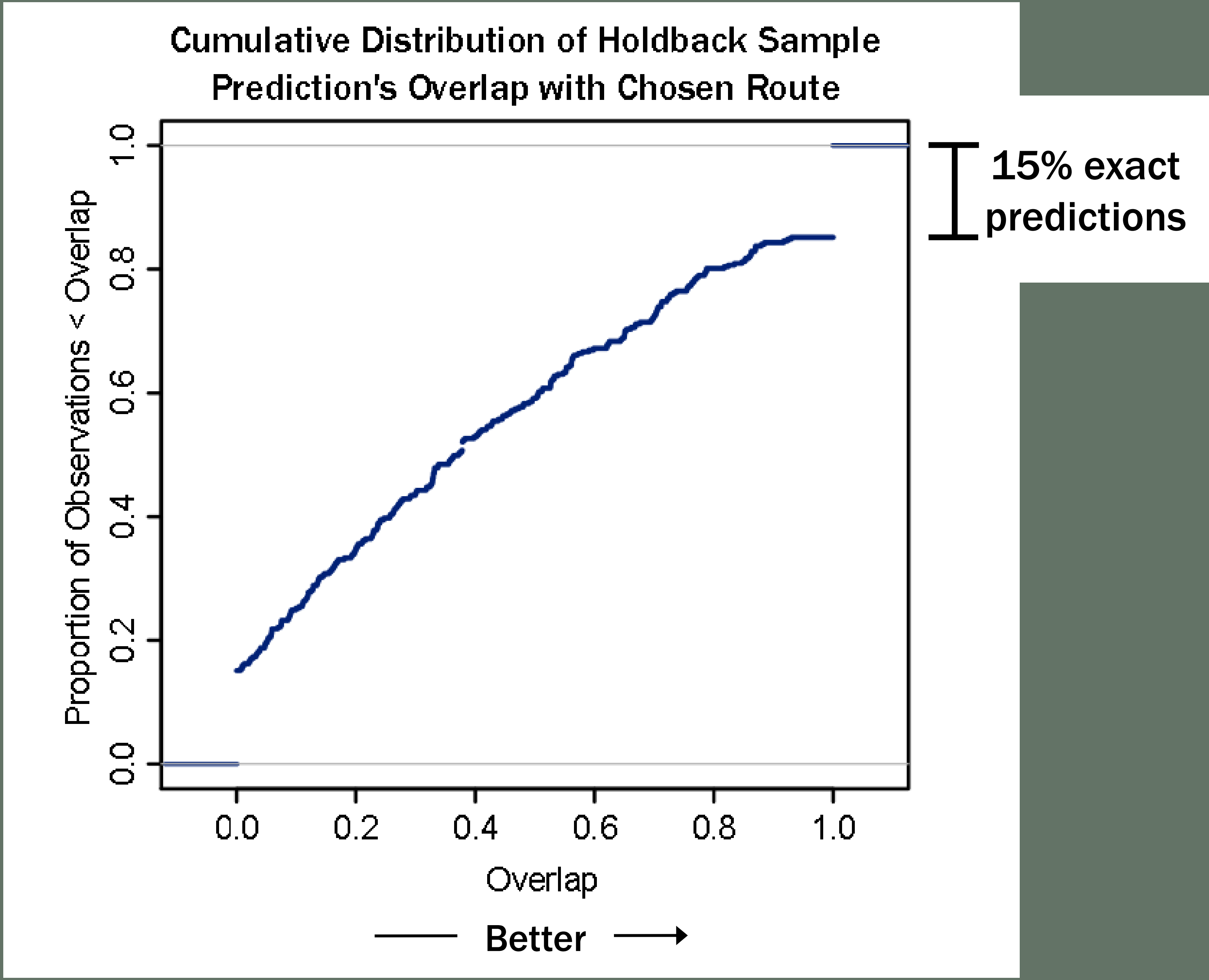
Attribute	Coef.	SE	*t*-stat.	*p*-val.
Length (mi)	–1.05	0.09	–11.80	0.00
Turns per mile	–0.21	0.02	–12.15	0.00
Prop. wrong way	–13.30	0.67	–19.87	0.00
Prop. bike paths	1.89	0.31	6.17	0.00
Prop. bike lanes	2.15	0.12	17.69	0.00
Cycling freq. < several per wk.	1.85	0.04	44.94	0.00
Prop. bike routes	0.35	0.11	3.14	0.00
Avg. up-slope (ft/100ft)	–0.50	0.08	–6.35	0.00
Female	–0.96	0.22	–4.34	0.00
Commute	–0.90	0.11	–8.21	0.00
Log(path size)	1.07	0.04	26.38	0.00

2,678 weighted observations, $\rho^2 = 0.28$

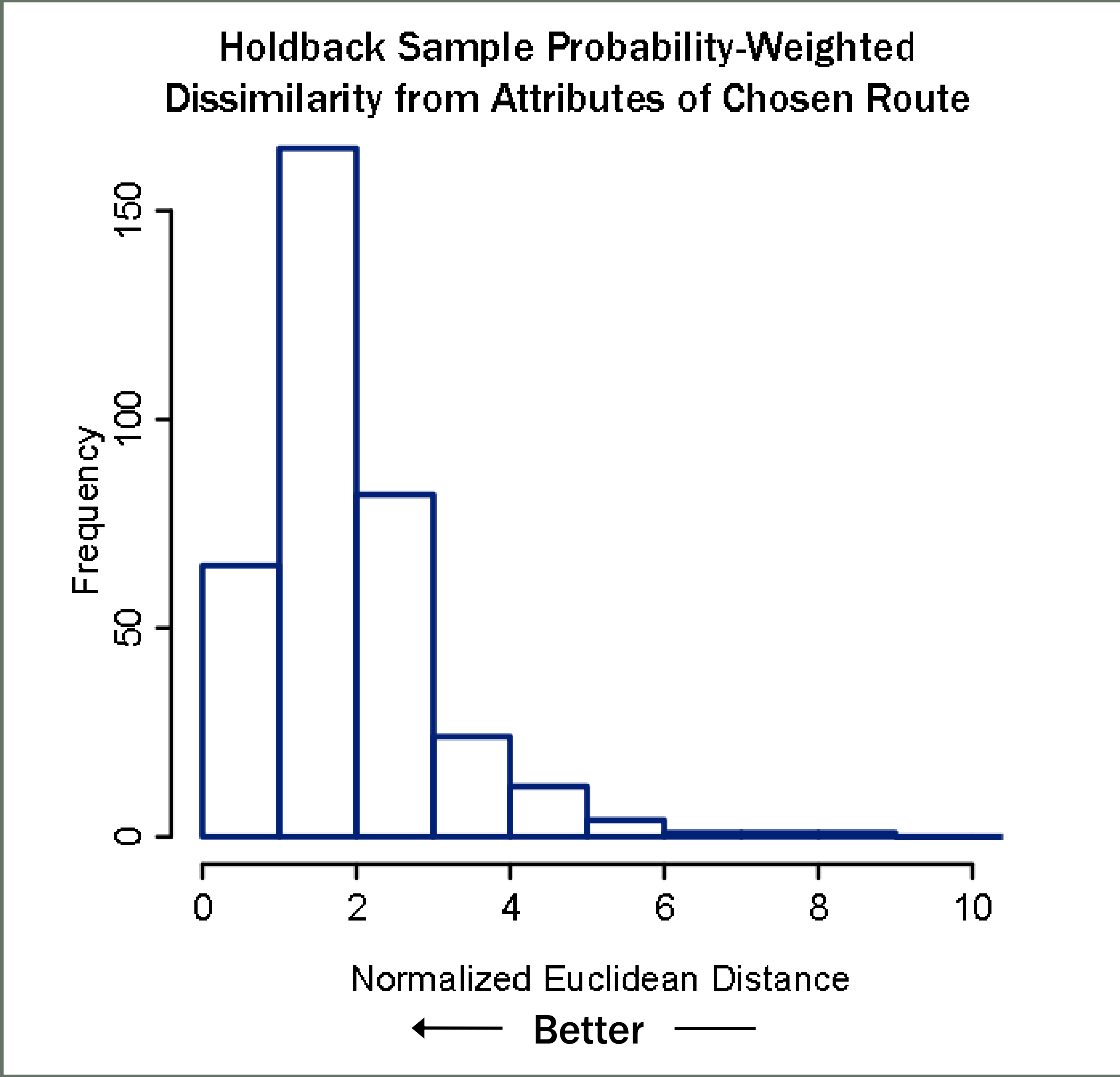
Average marginal rates of substitution

MRS of Length on street for	Value	Units
Length on bike paths	0.57	none
Length on bike lanes	0.49	none
Length on bike routes	0.92	none
Length wrong way	4.02	none
Turns	0.10	mi/turn
Total rise	1.12	mi/100ft

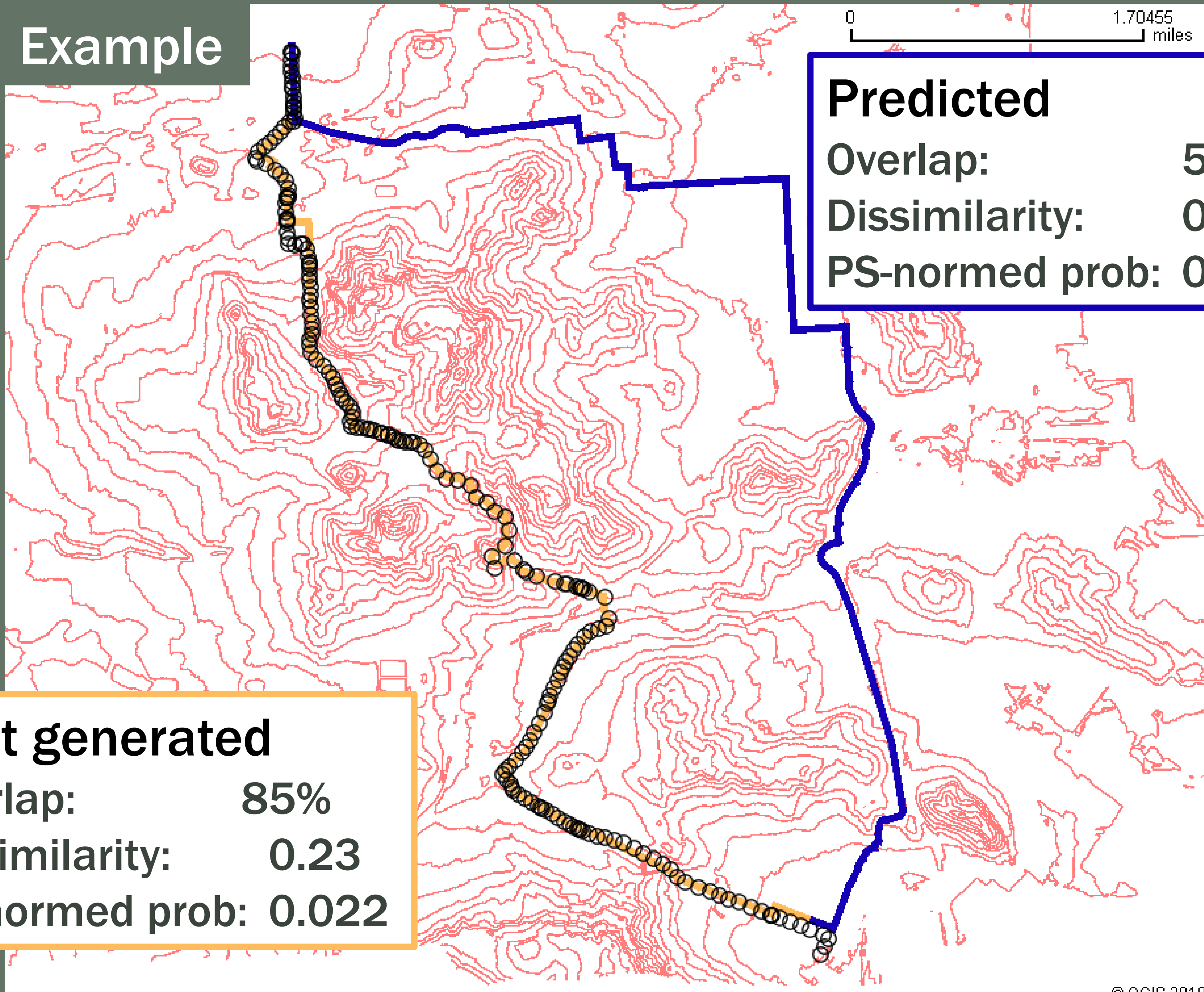
User benefit of bike lanes: $0.98 per mile per trip



Cumulative Distribution of Holdback Sample
Prediction's Overlap with Chosen Route
Proportion of Observations < Overlap
0.0
0.2
0.4
0.6
0.8
1.0
Overlap
15% exact
predictions
Better


Holdback Sample Probability-Weighted
Dissimilarity from Attributes of Chosen Route
Frequency
0
50
100
150
0
2
4
6
8
10
Normalized Euclidean Distance
Better

Example



Predicted

Overlap: 5%

Dissimilarity: 0.83

PS-normed prob: 0.025

Best generated

Overlap: 85%

Dissimilarity: 0.23

PS-normed prob: 0.022

Trip Assignment & Next Steps

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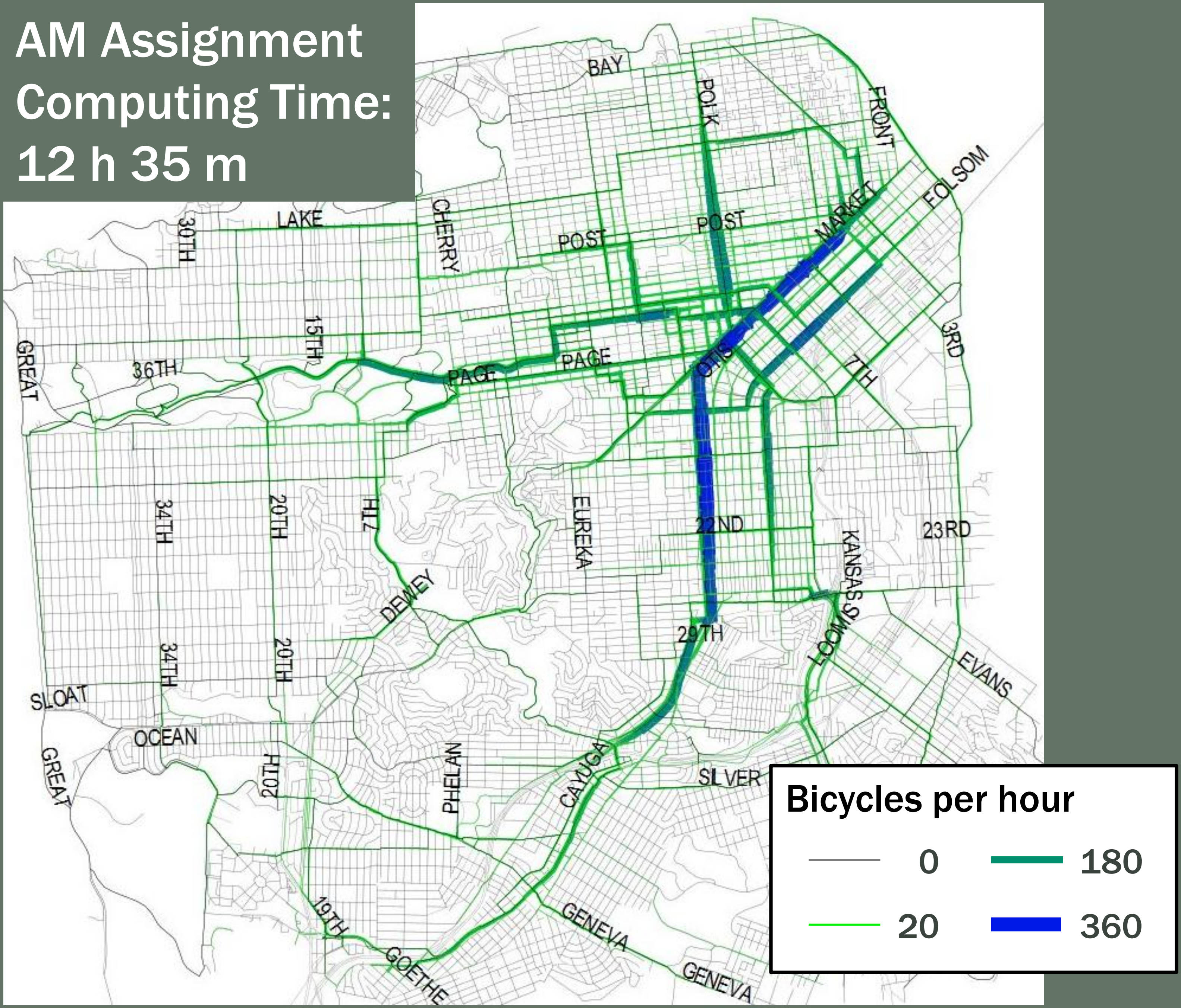
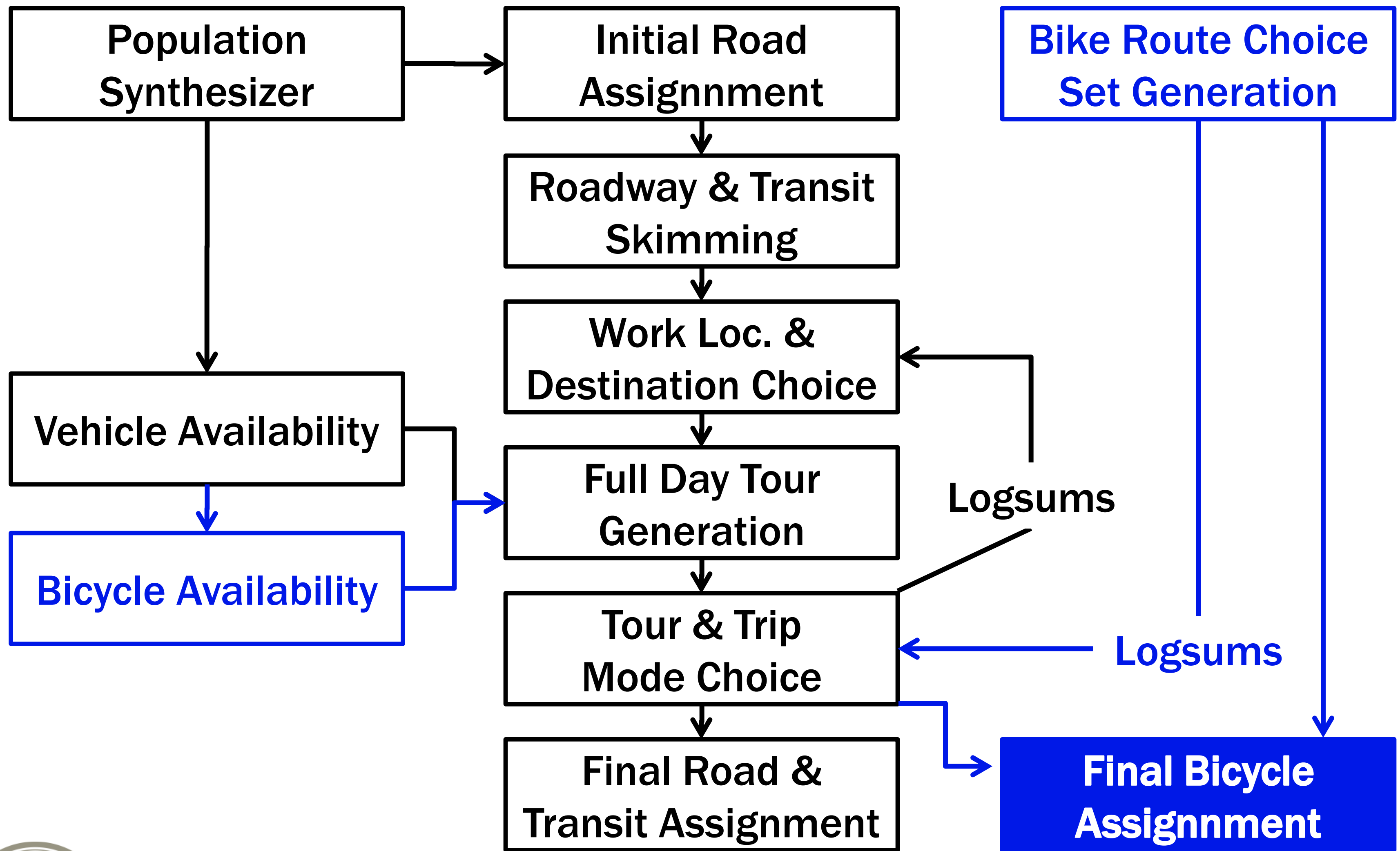
AM Assignment Computing Time: 12 h 35 m



Next steps for SF-CHAMP



Acknowledgements

Nadine Schüssler Kay Axhausen

Contact

Jeff Hood, UC Berkeley: jeffnhood@gmail.com

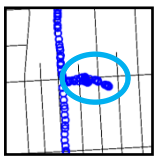
Billy Charlton, SFCTA: billy.charlton@sfcta.org

Matt Paul, MoPimp Productions: www.mopimp.com

Recap

Introduction

CycleTracks for iPhone & Android



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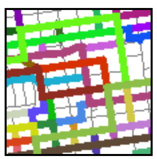

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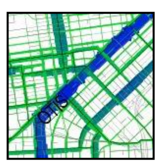
Model estimation & validation



Trip assignment & next steps