Traffic dynamics in Transportation Networks

Rajarshi Basak

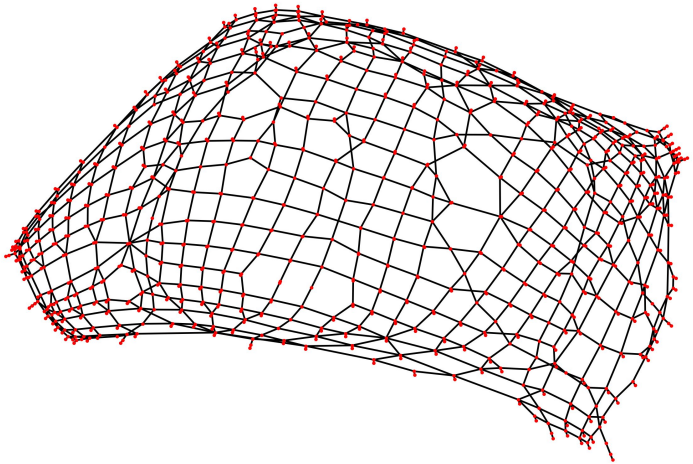
Course Project

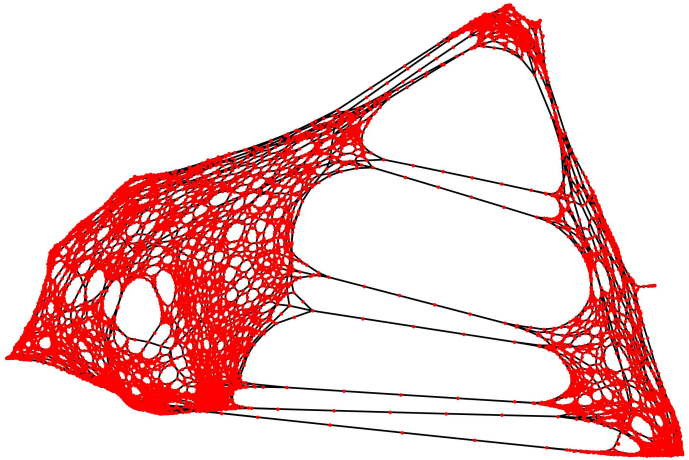
CSCI - 5352 (Network Analysis and Modeling)

Fall 2018

Introduction

- Network of roads and junctions
- Traffic flow between junctions
- Anaheim, CA ; Chicago, IL ; Philadelphia, PA ; Austin, TX





Data

- https://github.com/bstabler/TransportationNetworks/tree/master/Anaheim

Ben Stabler
bstabler

Developer of transportation systems modeling software

bstabler / **TransportationNetworks**

Watch 32 | Star 114 | Fork 101

Code | Issues 7 | Pull requests 0 | Projects 0 | Insights

Transportation Networks for Research

networks | dataset | traffic

50 commits | 1 branch | 0 releases | 7 contributors

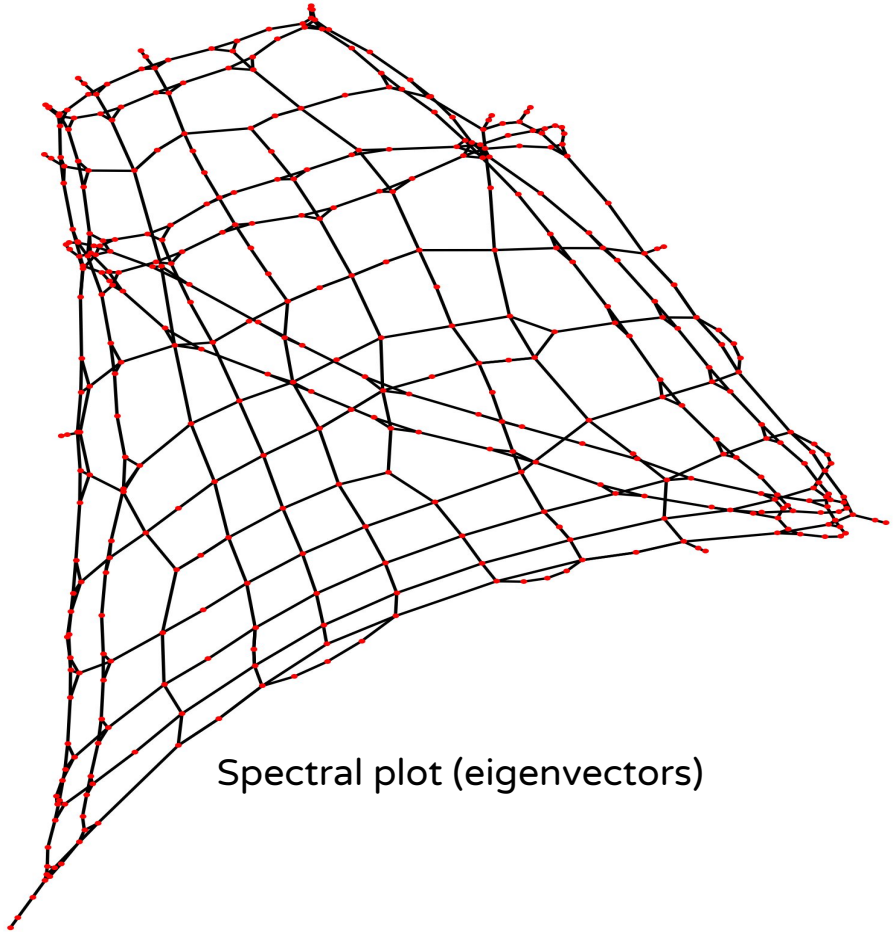
Branch: master | New pull request | Find file | Clone or download

bstabler Update README.md — Latest commit 3732bcd on Oct 24

Anaheim	networks	3 years ago
Austin	networks	3 years ago
Barcelona	networks	3 years ago
Berlin-Center	networks	3 years ago
Berlin-Friedrichshain	networks	3 years ago
Berlin-Mitte-Center	networks	3 years ago
Berlin-Mitte-Prenzlauerberg-Friedrich...	networks	3 years ago
Berlin-Prenzlauerberg-Center	networks	3 years ago

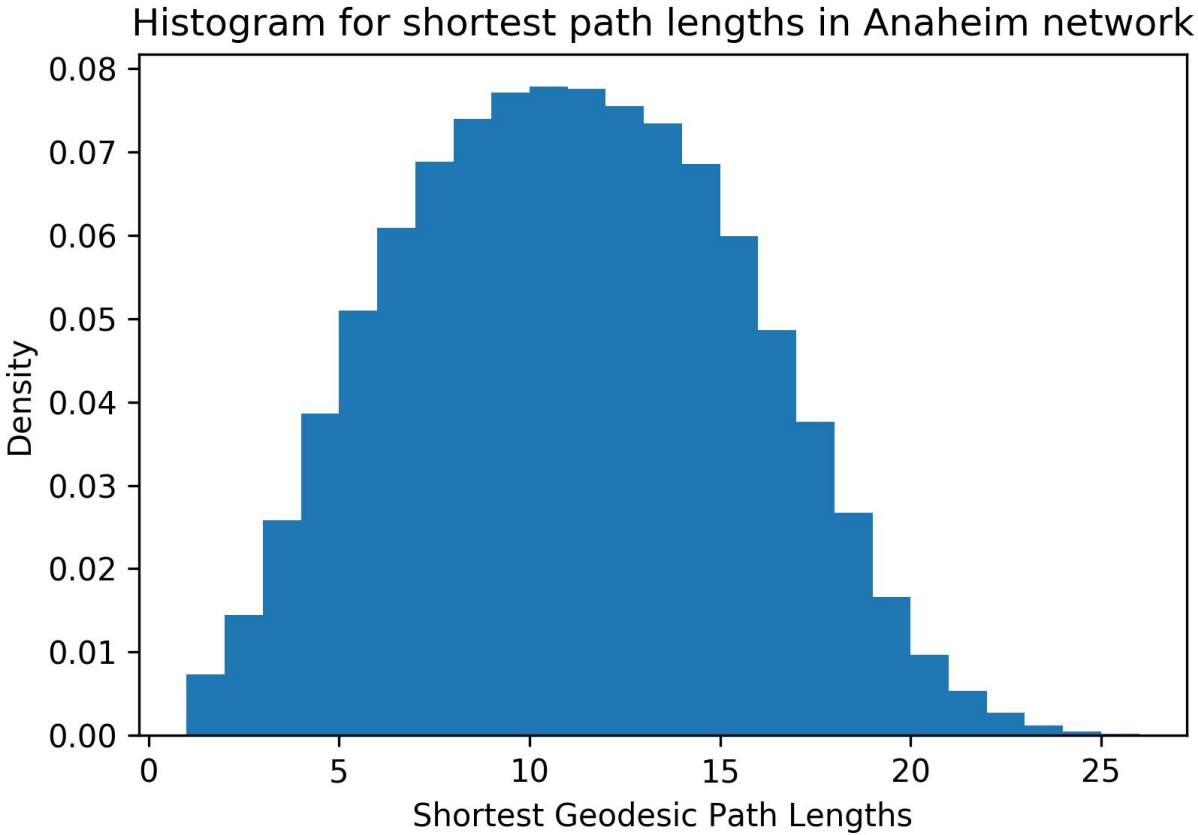
The Anaheim Network

- 1992
- Files
  - Anaheim-flow.tntp
  - Anaheim-net.tntp
  - Anaheim-trips.tntp
- .tntp -> .txt
- 416 nodes
- 914 edges
- 38 zones

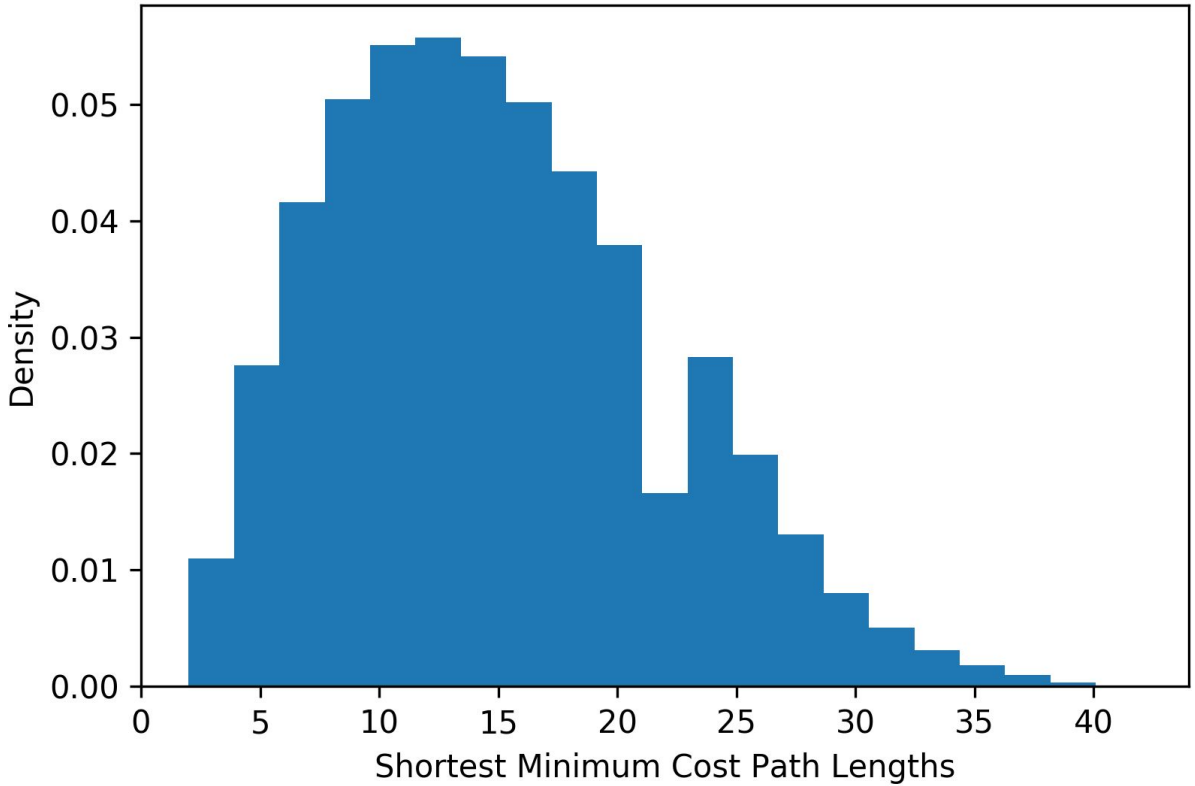


Spectral plot (eigenvectors)

Shortest Paths (geodesics)



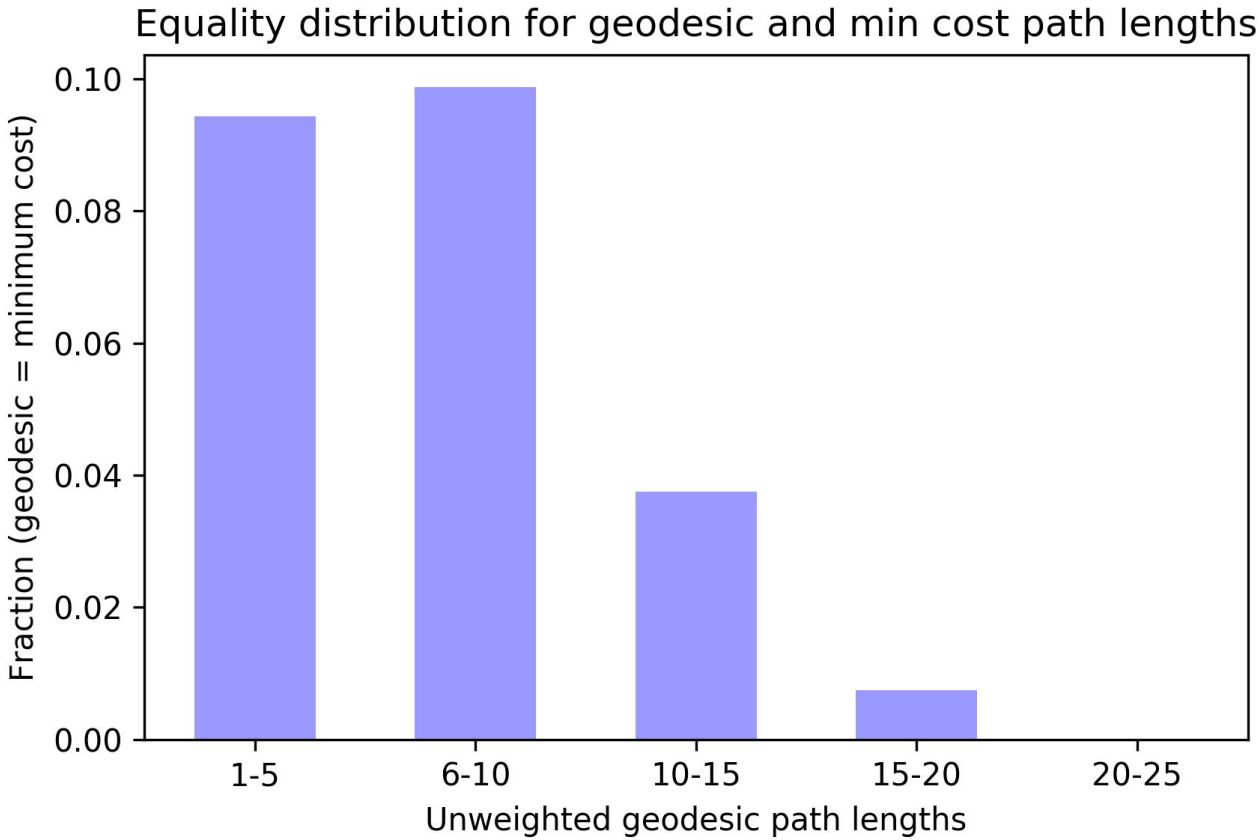
Shortest Paths (minimum costs)



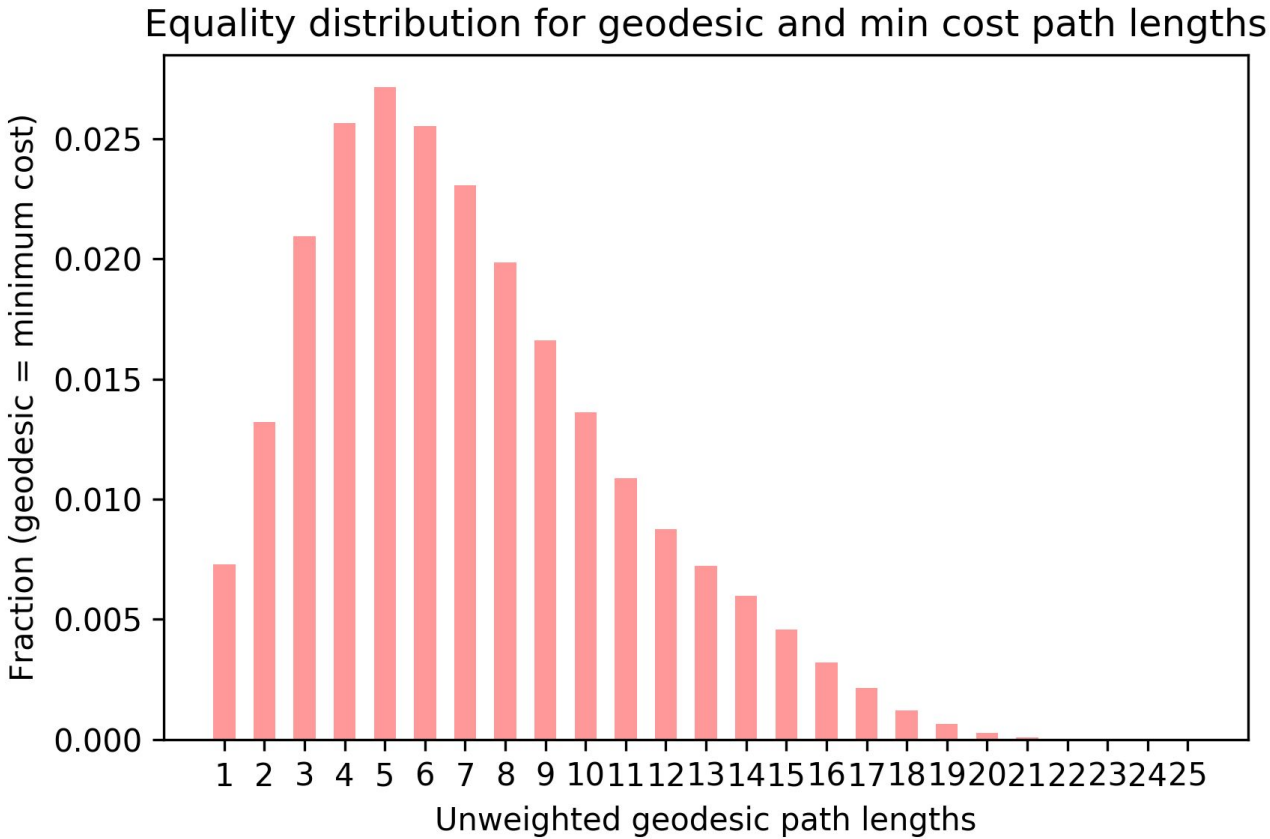
Shortest Paths (geodesics = minimum costs) ?

- Load graph (unweighted/weighted)
- Shortest path (u/w) for all pairs
  - Dijkstra’s algorithm
- Count paths for which u = w
- Plot as a function of geodesic path length
- Expectation
  - Large fraction equal for smaller geodesic path length
  - Fraction should decrease rapidly for larger path lengths

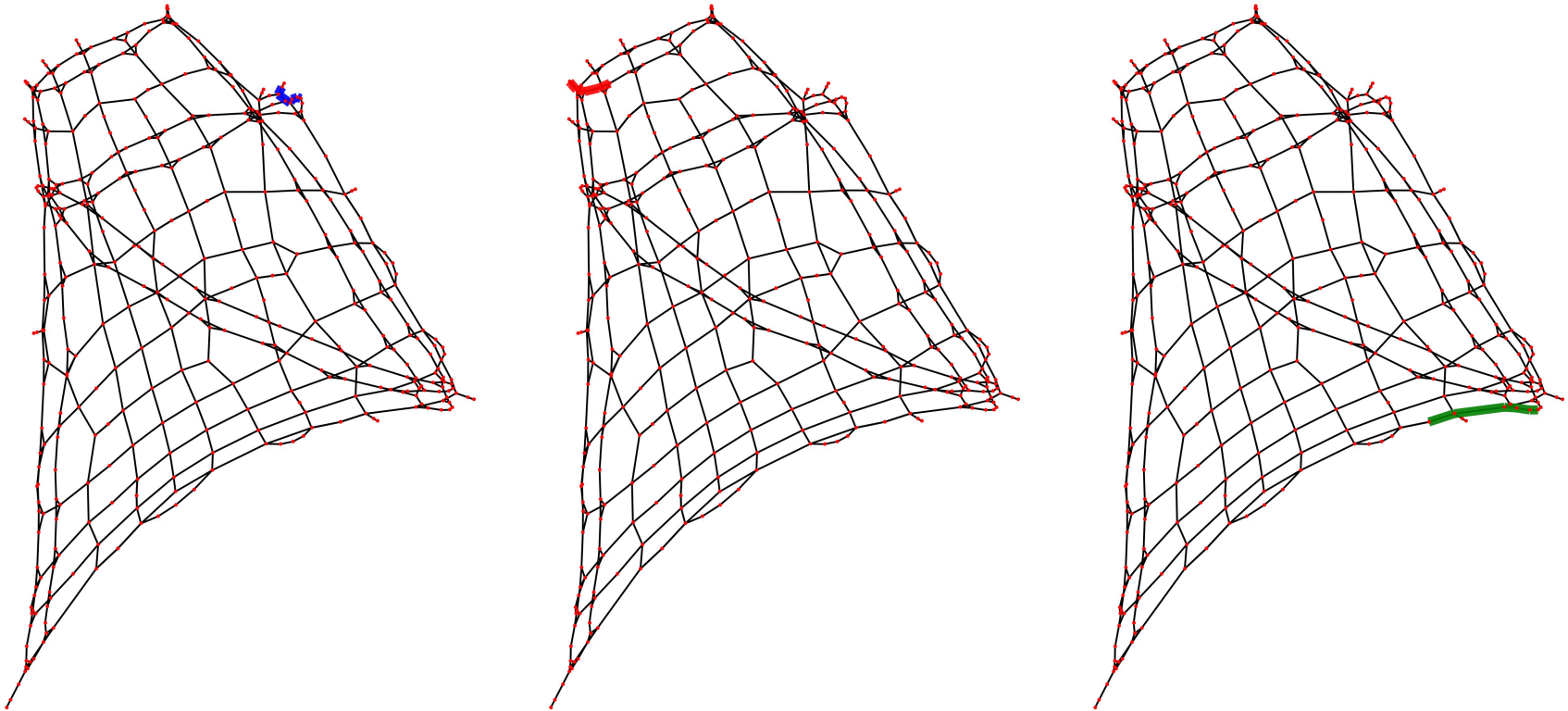
Shortest Paths (geodesics = minimum costs) ?



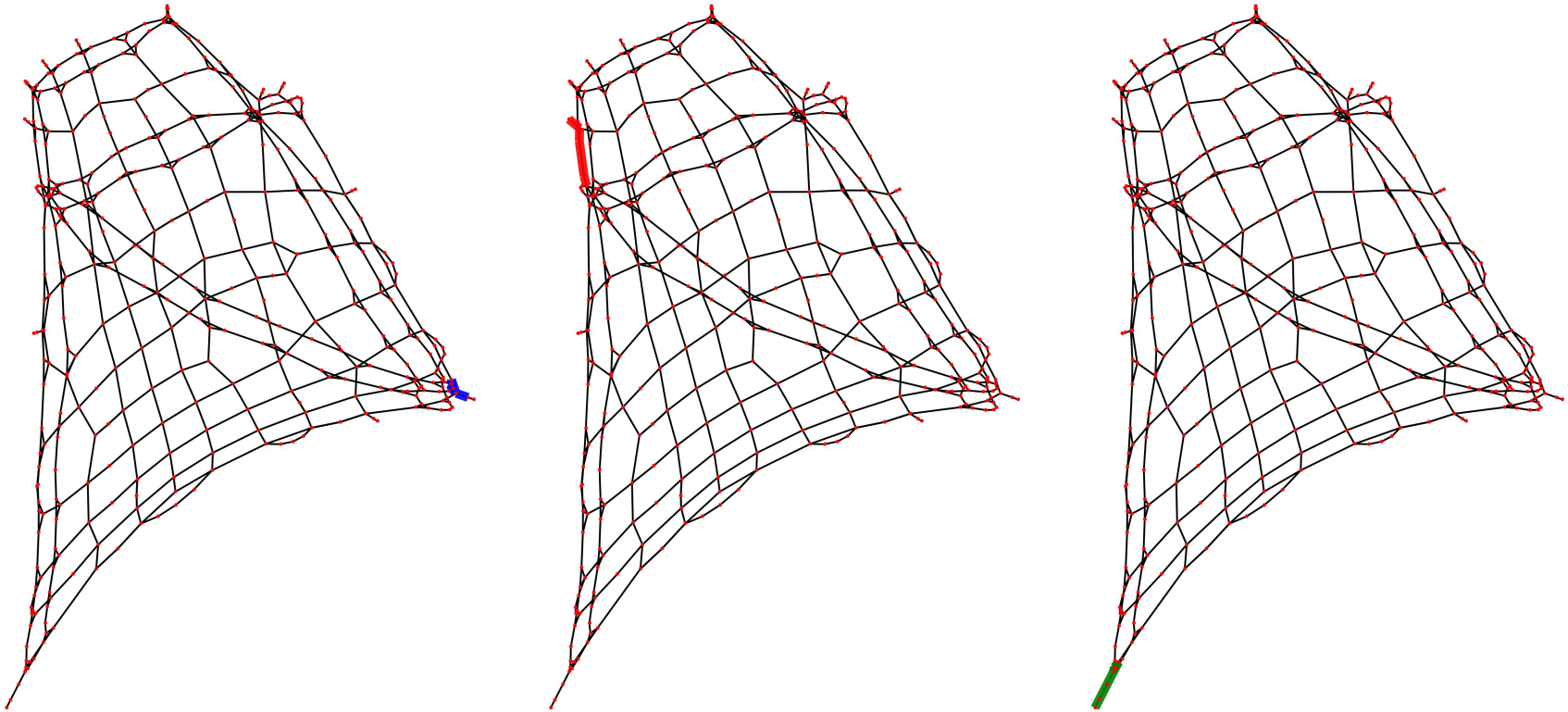
Shortest Paths (geodesics = minimum costs) ?



Shortest Paths (Path Length = 5)



Shortest Paths (Path Length = 5)



Perturbations

- Removing nodes
- Removing edges
- Removing nodes AND edges
- Altering edge costs/attributes

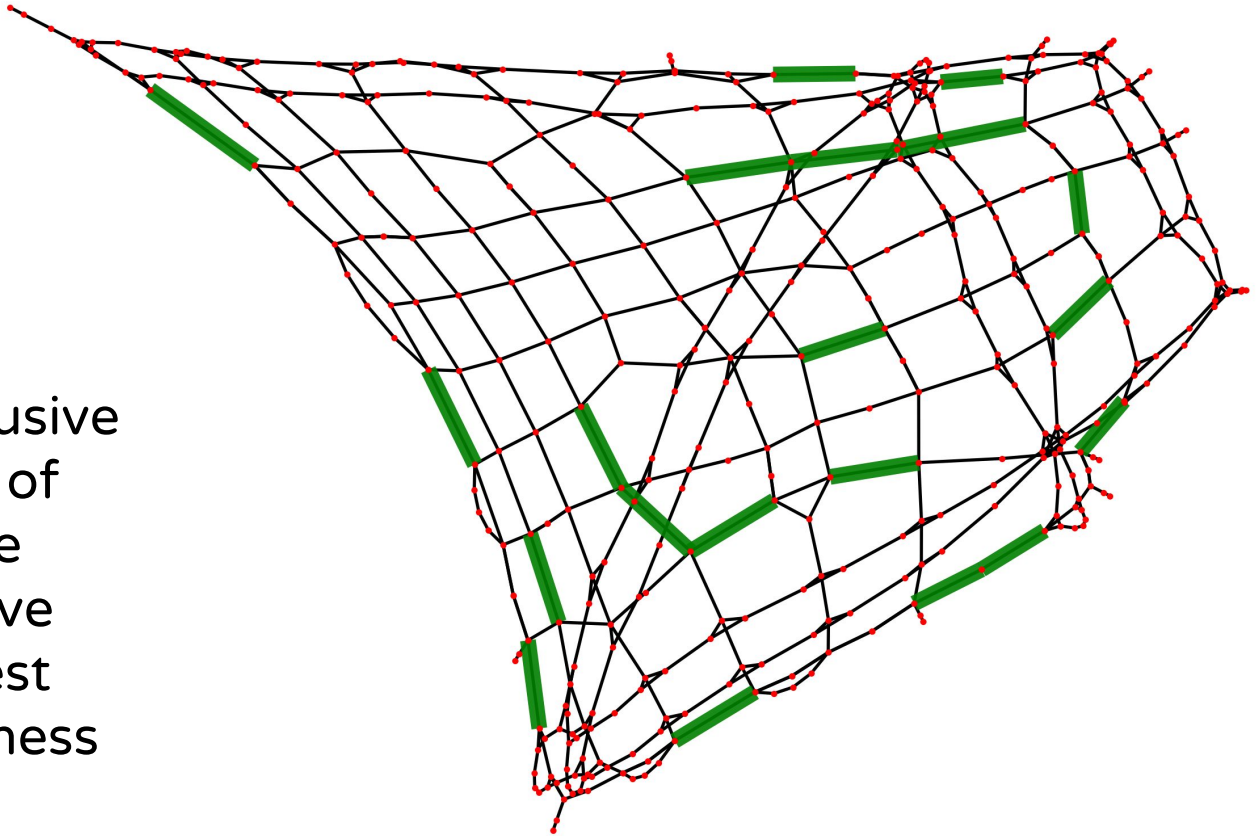
Dynamical Importance of Nodes (Junctions)

- Remove an edge
  - Block ALL traffic
  - Detour around that edge
- Drop in overall transport speed
  - ~ Increase in overall cost
- Inspect shortest paths for all pairs before and after removing an edge
- Fetch betweenness centrality of edge
- Expectation : Higher the centrality of removed edge, higher the change (increase) in shortest path when edge is removed

Betweenness centrality for edges

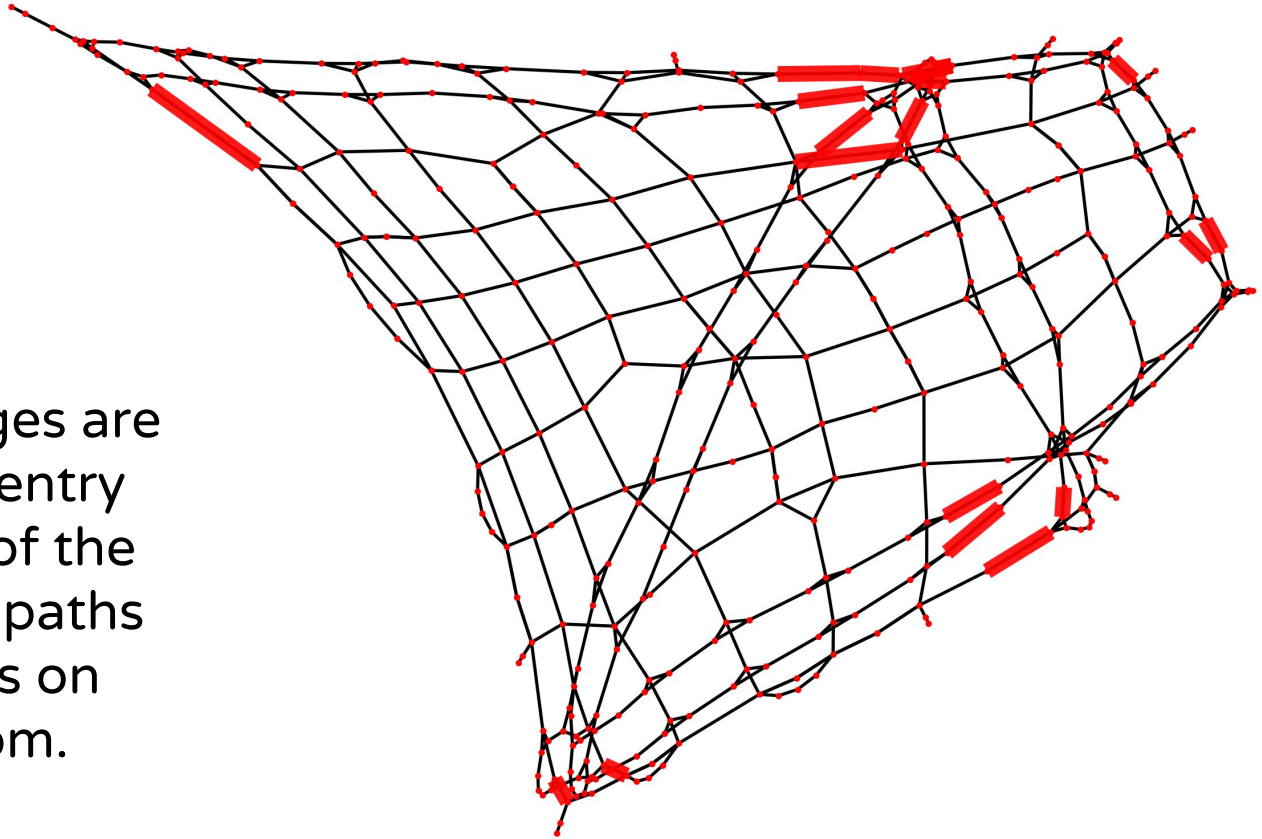
- Fraction of all paths that traverse through given edge
- Current flow model
- Resistance = Cost
- Current = Traffic
- Kirchoff’s Law of current distribution

Betweenness centrality for edges (unweighted)



No conclusive evidence of why these edges have the highest betweenness

Betweenness centrality for edges (weighted)



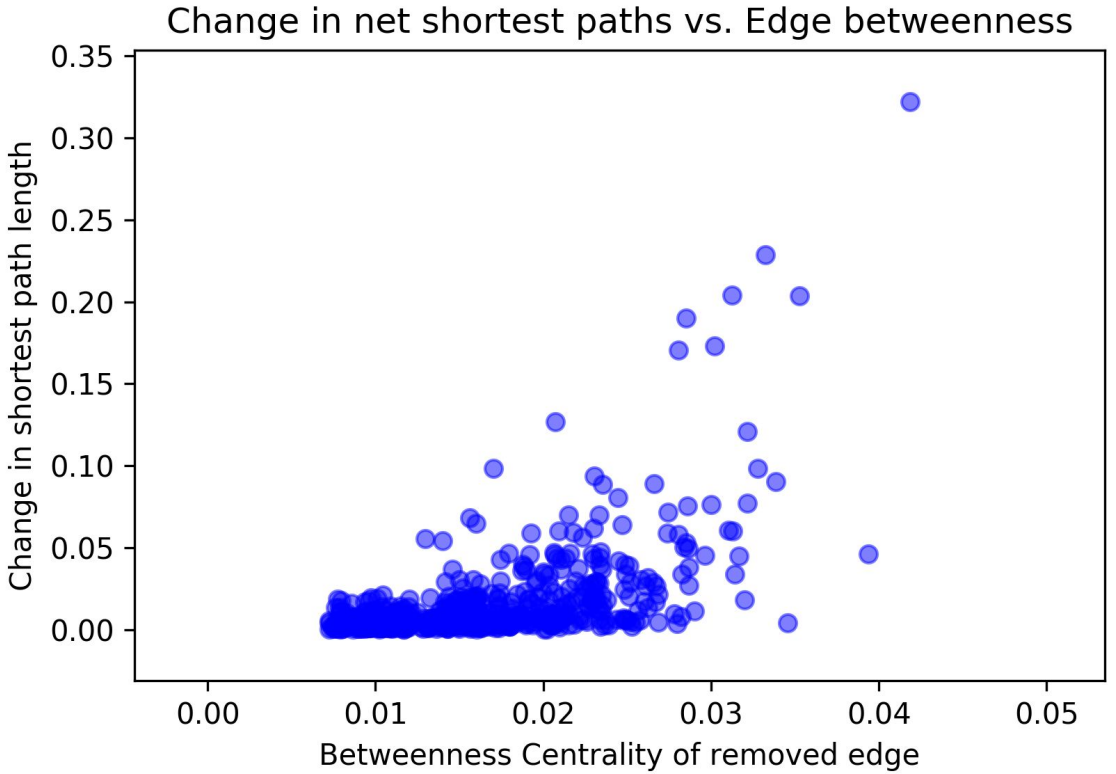
Most edges are near the entry and exit of the diagonal paths and paths on the bottom.

Dynamical Importance of Nodes (Junctions)

- Change in net shortest path length vs. betweennness centrality of removed edge
  - Unweighted
  - Weighted
  - Expectation : Greater the centrality, greater the drop in general
- Correlation between centralities of edges for the weighted and unweighted case (when edge is removed)
  - Expectation : a 45 degree scatterplot
- 3d plot of change in total shortest path length as a function of weighted and unweighted centralities of removed edges
  - Expectation : a 45 degree scatterplot with a rise in z axis for larger values of both the centralities

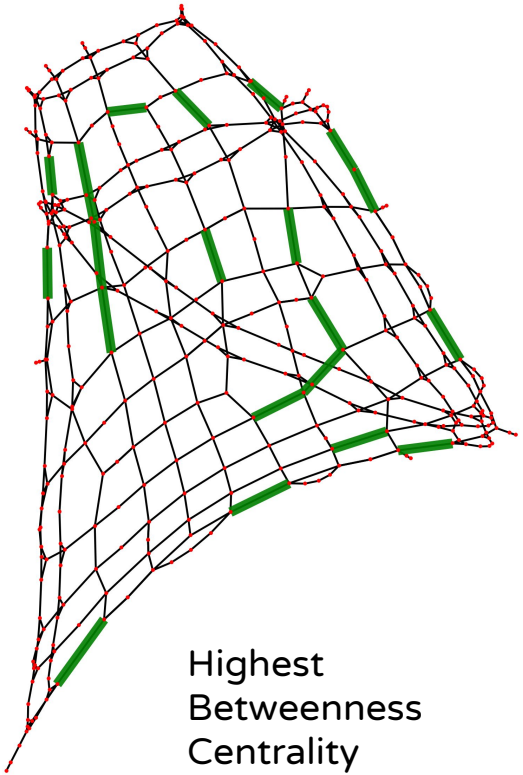
Dynamical Importance (Unweighted)

- Cost before = **10.63**
- Most edges (even with high betweenness) don't have a huge effect
  0.01 - 0.03
- A handful of edges have moderate effect
  0.05 - 0.12
- Only a few have a large effect that scales linearly
  0.17 - 0.34

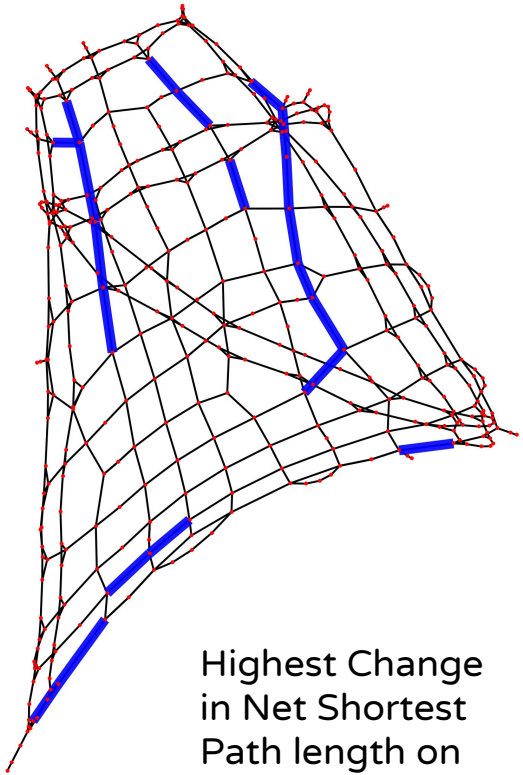


Dynamical Importance from betweenness

Some overlap between edges for highest betweenness centrality and highest change in net shortest path lengths when edge is removed

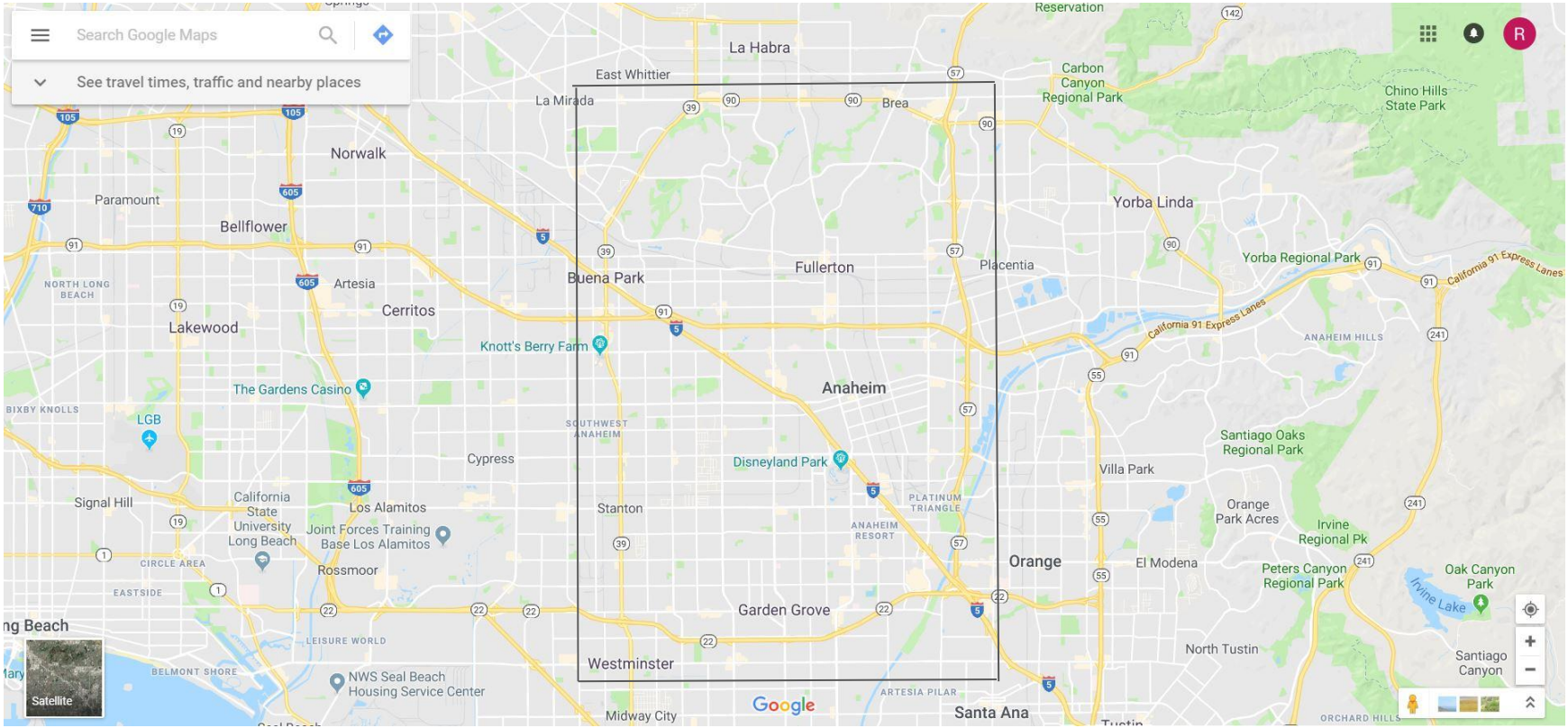


Highest Betweenness Centrality



Highest Change in Net Shortest Path length on removal of edge

Current map of Anaheim (Google Maps)



References

- Models and algorithms for road network design: a review and some new developments ; Hai Yang Michael,G. H. Bell; Pages 257-278; https://doi.org/10.1080/01441649808717016
- A review of urban transportation network design problems; Reza Zanjirani Farahani, Elnaz Miandoabchi, W. Y. Szeto, Hannaneh Rashidi; https://doi.org/10.1016/j.ejor.2013.01.001
- The Structure of Interurban Traffic: A Weighted Network Analysis; Andrea De Montis, Marc Barth´elemy, Alessandro Chessa, Alessandro Vespignani; https://doi.org/10.1068/b32128

Thank you!