Bicycle-route design

Glencora Borradaile

Bicycle routes are become exceedingly popular in American cities. The design of bicycle routes can be as simple as identifying roads that are safe to cyclists to redirecting vehicular traffic away from roads that allow cyclists to pass through uninhibited to constructing new paths dedicated to cyclists and pedestrians. The aim of this project is to

(A) model the bicycle-route design problem as an optimization problem in graphs,

(B) balance the simplicity of the model with the practicality of real-life bicycle-route design, and

(C) develop or modify existing algorithms to solve the resulting optimization problems.

Part (A) will involve problems in planar graphs, which are a natural model for road networks, particularly in neighbourhoods which have few bridges and tunnels. Likely candidate network design problems include:

Survivable network design Find a minimum-cost subgraph of the original graph that has a prescribed number of paths between each pair of nodes. This network will allow for several options for cyclists.

Spanners Find a minimum-cost subgraph such that distances in the subgraph are not much greater than distances in the original graph. Such a network minimizes the *detour* cost of using a bicycle route.

Connectivity augmentation Choose edges to add to a graph in order to shorten distances or increase the number of paths between destinations. This could be used to augment an existing bicycle network to improve conditions.

The problems above are classic network design problems; however, the bicycle-route design problem will involve creatively combining these problems. An additional *novel* objective is to find a subgraph that not necessarily connects prescribed destinations but is simply *near* every destination. That is, the bicycle route need not visit every house, but only be within some tolerated distance of every house.

Part (B) will involve speaking with traffic engineers, city planners and (yes, they exist) bicycle-route designers to determine what needs could be met by an optimization problem.

In Part (C), the student will work closely with me and collaborators and learn what is involved in designing and analyzing a new algorithm.