6.336 Project Abstract
DeJuan M Anderson (dejuan@mit.edu), Shi Kai Chong (cshikai@mit.edu), Nina Lutz (nlutz@mit.edu)

Motivation

Drivers in the United States can waste up to 82 hours in traffic annually. In addition to incurring an annual cost of 124 billion dollars, road congestion also causes environmental damage. With increasing levels of population and environmental concerns, traffic congestion is becoming an urgent issue that city planners and policy makers have to consider, and tools that help analyze urban transportation are becoming increasingly relevant. In this project, we simulated and studied traffic behavior in Cambridge during peak hours, when people are commuting between work and home in the region shown in Figure 1.

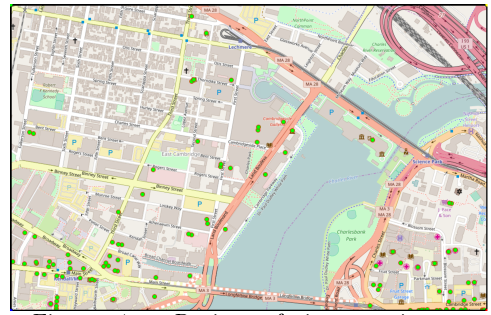


Figure 1: Region of interest in Cambridge.

Problem Formulation

Network

Input: Flow of cars from origins, flow of cars into destinations $\equiv \boldsymbol{f_{s,i}}$
Output: Congestion as a ratio of travel time to free flow travel time

Nodes: Geographical decision points	Components: Roads
Signals: Time from origin to node i, $\equiv \boldsymbol{T_i}$	Signals: Flow of cars $\frac{cars}{time}$, $\equiv \boldsymbol{f_a}$
Parameters: Free-flow-travel-time to node i, $\equiv \boldsymbol{T_{0,i}}$	Parameters: Capacity of road, $\equiv \boldsymbol{K_a}$, Proportionality constant $\equiv \boldsymbol{\beta_a}$

Equations

If $f_{i,j}$ is the flow from node i to node j, where A(i) is the set of all nodes connected to node i, the conservation of traffic flow gives us Equation 1, where where $f_{s,i}$ represents flow as a source or sink, and is 0 for all non-sources and sinks.

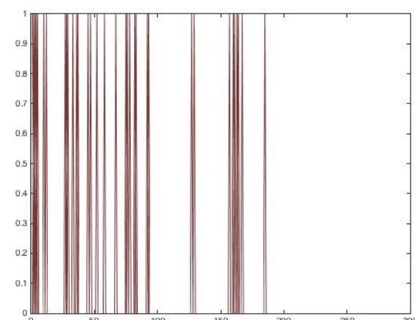
$$\sum_{j \in A(i)} f_{i,j} = f_{s,i} \text{ for all } i. \quad (1)$$

If we treat the cost of travel as the time required, the Bureau of Public Roads (BPR)[2] gives us the formulation represented by Equation 2, where $T_{0,i}$ is freeflow time from origin to point i.

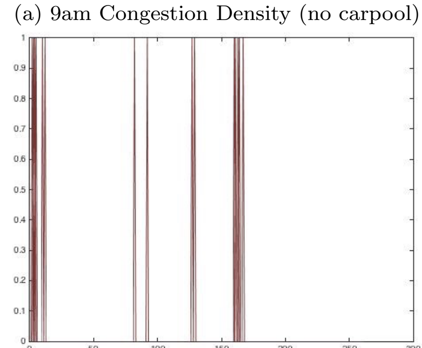
$$T_i - T_j = (T_{0,i} - T_{0,j})(1 + \beta_a (\frac{f_a}{K_a})^4) \text{ for all } a. \quad (2)$$

Results

We have investigated congestion, measured in terms of $\frac{T_i}{T_{0,i}}$, during hours when people are commuting between work and home in Cambridge. We have created a plot of the times during which the time taken for travel exceeds twice the free flow time, an indicator of heavy congestion. We measured this for steady state conditions when traffic is worse, then compared the congestion if we were to assume all drivers carpooled. Graphs comparing the density of congested roads are given in Figure 2. From these graphs, we can see that mandated carpooling drastically lowers the congestion density. Additionally, we have tested the road network with a constant input, equal to the average flow traffic over an entire day, and tested whether or not the current infrastructure can support the expected traffic. We found that the current roads can support the average amount of traffic with much less congestion than is usually experienced; therefore, we conclude that congestion is an usage problem that could be solved with policies regulating the average load at a given time.



(a) 9am Congestion Density (no carpool)



(b) 9am Congestion Density (w/ carpool)

Figure 2: Comparison of carpool effects.

References

[1] “A Circuit Simulation technique for Congested Network Traffic Assignment”, Cho,H.J. & Huang,H. AIP Conference Proceedings, 963, 993(2007)

[2] ”The Determination of Urban Traffic Movements with electrical analogues” James McCarthy Small