Dynamic Incentive Design for Transportation Systems with Unknown Value of Time

Ketan Savla
University of Southern California
ksavla@usc.edu

Project Objective

To infer traveler value of time from streaming traffic data and use it for dynamic congestion pricing

Problem Statement

Design an adaptive pricing algorithm to estimate value of time from traffic volume measurements on different routes and investigate the efficacy of the algorithm in controlled human subject experiments

Research Methodology

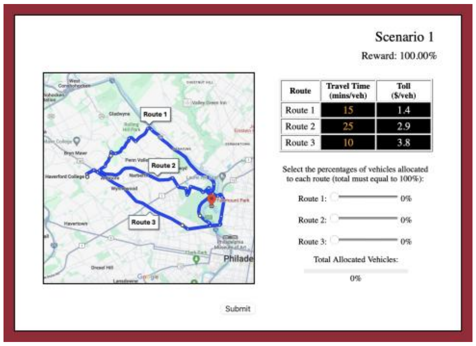
The estimation algorithm is designed for the following iterative setting. In each iteration, the input is congestion pricing and the output is Nash flow on different routes. The input pricing in each iteration is updated so that price is changed for a route in proportion to the volume on that route in the previous iteration. The equilibrium relation underlying the input-output data collected under such adaptive pricing is then inverted to learn the unknown value of time (VOT). The algorithm is implemented in a controlled setting where users make traffic assignment decisions on a computer screen. Marginal best pricing corresponding to the learned VOT is then implemented and the traffic assignment selected by the users is compared against social equilibrium, i.e., traffic assignment which minimizes average travel time.

Results

The proposed adaptive pricing algorithm augmented with appropriate randomization is shown to estimate value of time with high accuracy using few samples. Results from the laboratory experiments (see Fig 1 for the user interface) show that the estimated value of time using our adaptive pricing algorithm is consistently lower (in mean and variance) with respect to estimates obtained using an existing adaptive stated preference method (see Fig 2). The experiments also suggest that, under marginal pricing using our estimated VOT, users tend to choose traffic assignment which is quite close to social equilibrium (Fig 3).

	Δ Time (mins)	Δ Toll ($)
Option A	0	0
Option B	- 9	+ 3.1

(a)



(b)

Figure 1: user interface for adaptive pricing using (a) adaptive stated preference method and (b) our proposed adaptive pricing and estimation algorithm

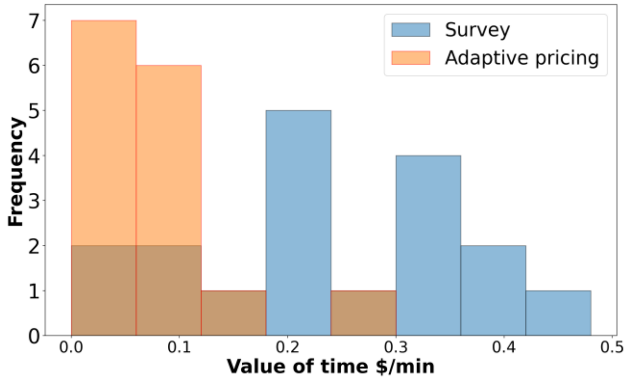


Figure 2: Comparing VOT estimates from adaptive stated preference method (survey) and from proposed adaptive pricing algorithm

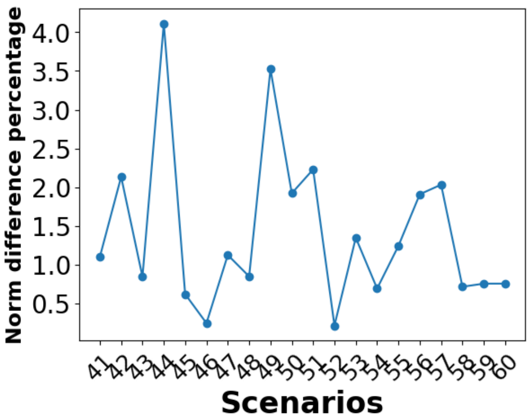


Figure 3: Percentage deviation between traffic assignment chosen by a sample user under marginal pricing with VOT estimate from our adaptive pricing algorithm w.r.t. social equilibrium traffic assignment.