New algorithms for parking demand management and a city scale deployment

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A city-scale deployment of on-line learning: LA ExpressPark, June 2012 - present

**Goal:** reduce congestion and underuse in on-street parking by (on-line) learning optimal demand based rates.

**Challenges:**
- Needs to be simple to act upon.
- Needs to be fair.
- Easy understand.
- Needs to work from day 1.

**Deployment in down-town LA:**
- Over 6000 dedicated sensors.
- First rate change in June 2012.
- Monthly changes.
- Real-time dynamic pilot 2013.
II. THE ECONOMIZING OF CURB PARKING SPACE—A SUGGESTION FOR A NEW APPROACH TO PARKING METERS

Uncontrolled parking of automobiles on the streets in large cities produces extremely unsatisfactory results both in terms of impeding the flow of traffic through the streets, and in causing would-be parkers to spend an undue amount of time and effort in finding a place to park and in making it in many cases impossible for persons who need to get to a given destination in a hurry to find a parking space within a reasonable distance of their destination. In addition, dense parking may make it difficult for trucks to make deliveries, may cause double parking for such...
Demand based pricing

To target ~85% parking occupancy through pricing
1. Prices close to market rates ensure most efficient use of the limited resource.
2. “Cruising” for parking (congestion and pollution) is reduced.
3. Extra revenue can support expansion of transit network and other initiatives.

Approach 1 Time-of-day:
Revise schedules at the end of the month

Approach 2 Real-time pricing:
Change prices more frequently based on demand
May rates (before start of pilot)
June rates (after first rate change)
Elements of the rate changing logic

\[ \int U(x, p)P(x|p)dx \]

Utility \quad Parking demand

**Vanilla solution:** Change rates based on average occupancy has a weakness: A too busy afternoon combined with a too busy morning can average to a perfect 85%.

Average utility \neq Utility of the average
Where demand exceeds supply, rates matter

**Just-right (Goldilocks)**

A is in **goldilocks** state: In the nearest 20 stalls to destination A, between 2 and 6 stalls are unoccupied

**Under-utilized, yet non-negligible charge**

A is in **under-utilized** state: In the nearest 20 stalls to destination A, more than 6 stalls are unoccupied, yet the rate exceeds 50cts/hr

**Congested**

A is in **congested** state: In the nearest 20 stalls to destination A, 0 or only 1 stall is unoccupied
Pricing engine, objectives, algorithms. A glimpse
A pricing engine

We can represent this data using a ternary plot.

- Justifiable
- Simple
- Close to LA’s original plans
- Converges to a distribution with desirable properties (Rate change logic induces a Markov chain on rate ladder. See paper for details)

Decrease rates here:
Significantly more underutilized than over utilized.

Increase rates here:
Significantly more congested than underutilized.

Don’t change the rates here:
It is both congested a reasonable fraction of time (suggesting rate increase), but also underutilized a reasonable fraction of the time (suggesting decrease). A single rate can’t solve both: wait until Phase II, time-of-day pricing.
First changes went into effect June 4th 2012

Of all blockfaces in pilot area:
- Decreased rates: 39%
- Increased rates: 14%

Data driven updates
- All changes supported by data using easy visualizations.

All expensive locations have a cheaper alternative nearby.
Do people change behaviour?
Change in behaviour after June 2012 change

Four situations:

Just-right (Goldilocks)

Not scarce: always enough parking and essentially free

Congested

Under-utilized, yet non-negligible charge
Questions?

Please see the paper for more details, e.g.:

- Convergence proof of the algorithm
- Algorithms to find data driven time-of-day windows
- More details on the impact of rate changes

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Winner of:
- MIT Technology Review 50 most disruptive companies.
- International Parking Institute Award of Excellence
- OECD International Transport Forum Innovation Award