New algorithms for parking demand management and a city scale deployment

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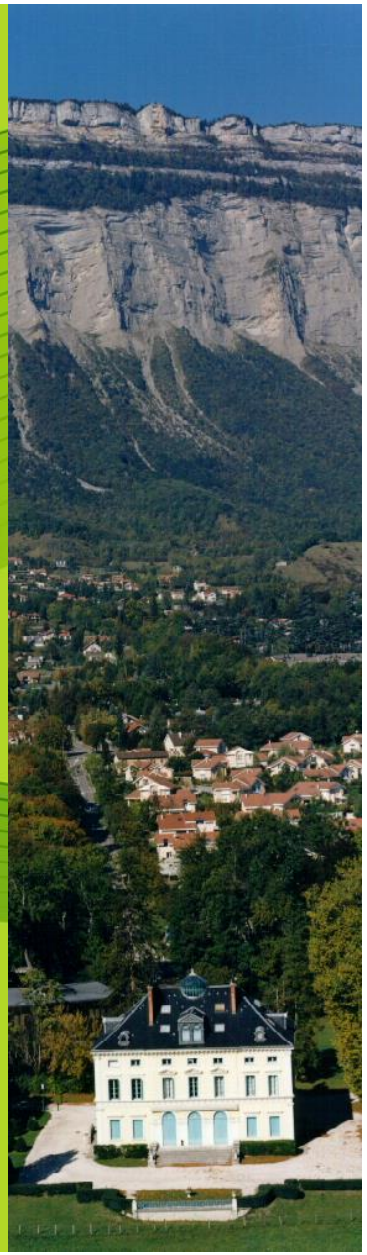

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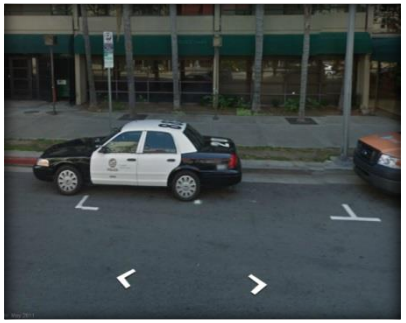
A city-scale deployment of on-line learning: LA ExpressPark, June 2012 - present

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.

Externality based pricing for publically owned utilities

William Vickrey, 1954.

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

In operation

Approach 2 Real-time pricing: Change prices more frequently based on demand

Small scale pilot

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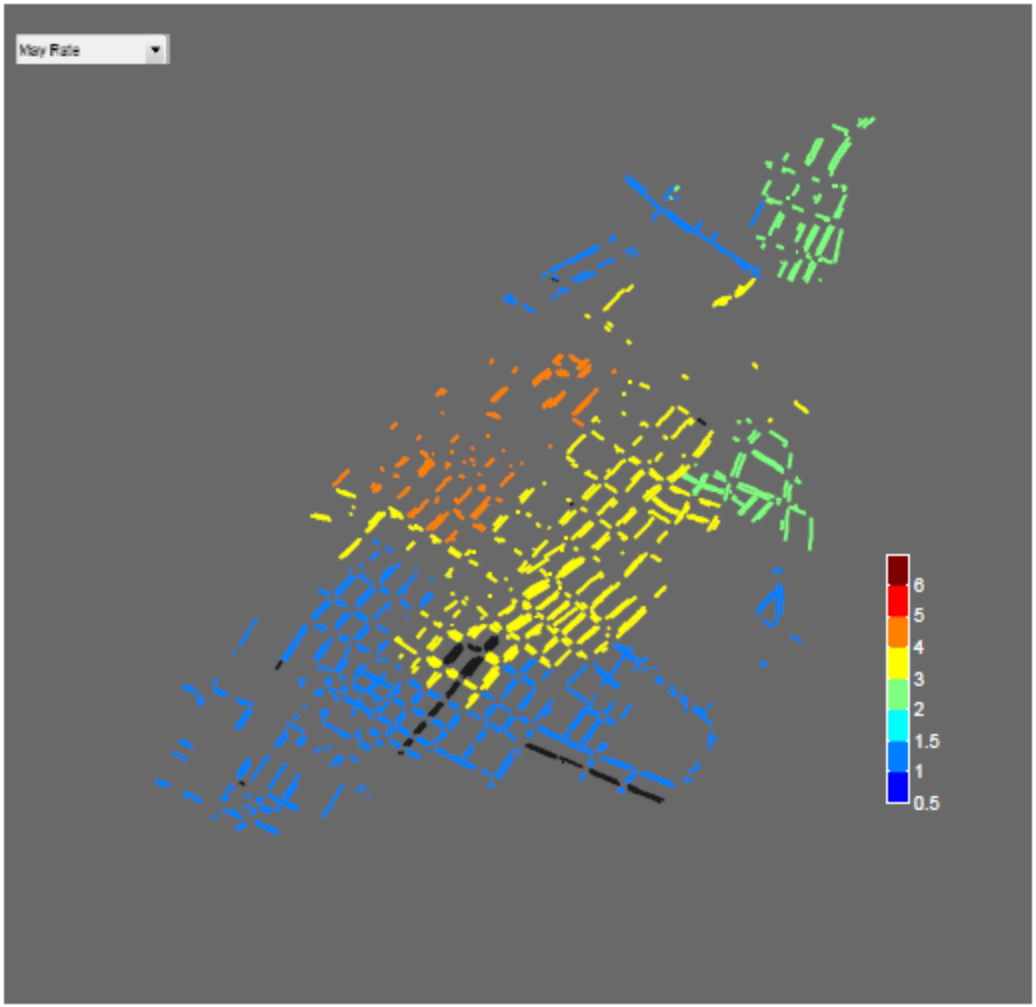
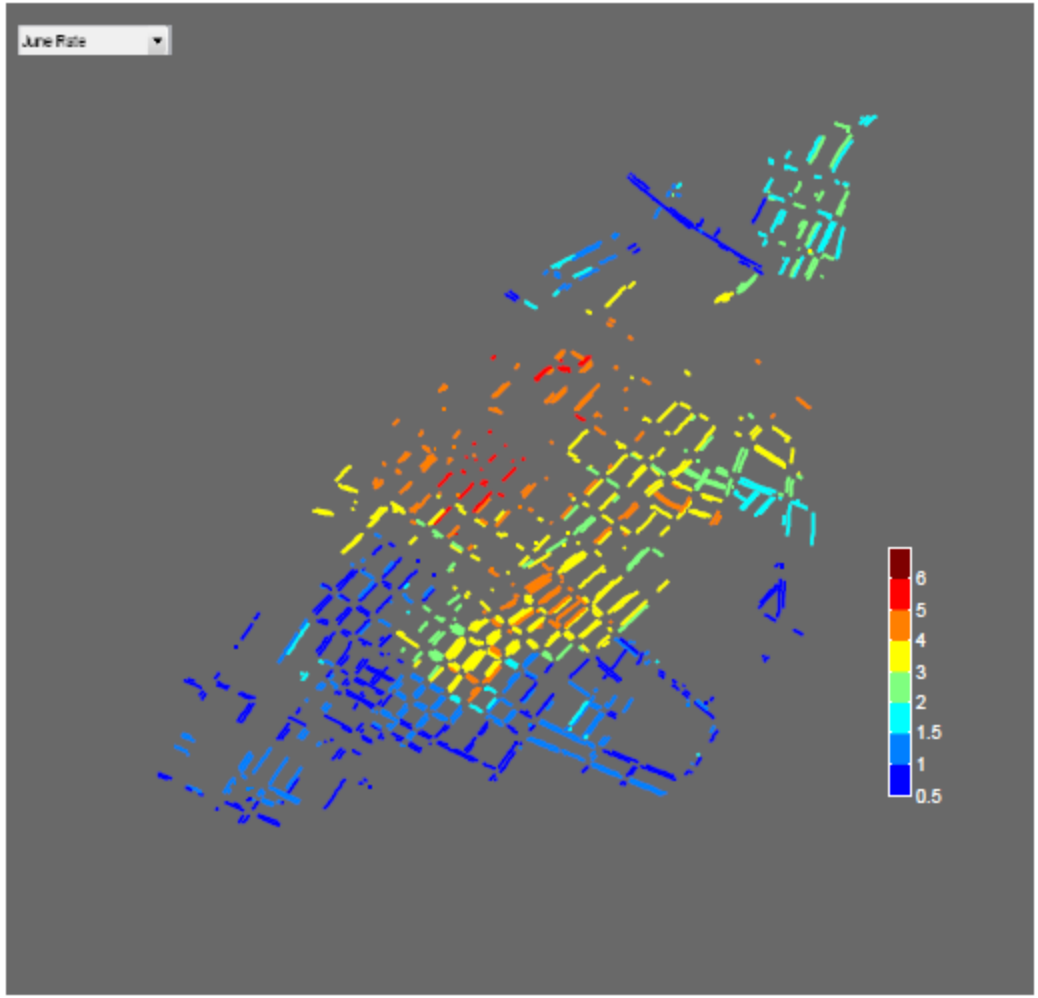
May rates (before start of pilot)



June rates (after first rate change)



Elements of the rate changing logic

$$\int U(x,p)P(x|p)dx$$

Utility 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 ≠ 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

Table 20: Blockface details

Operating hours	9AM-4PM Mon-Sat, TANS 7AM-9AM,
Number of sensors	3
Rate	3

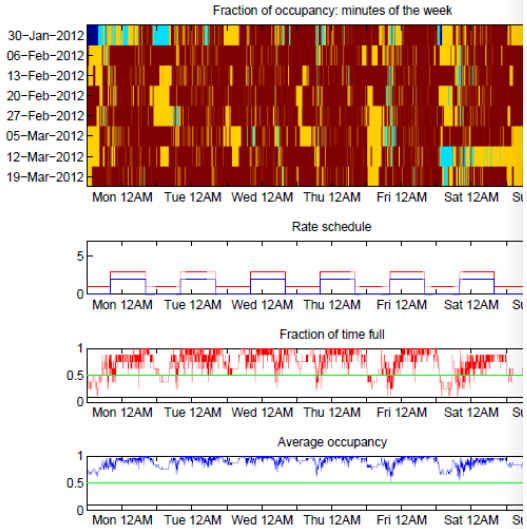


Figure 39: Week view of blockface 101 ASTRONAUT ONI

3.200 500 E 3RD ST

Table 200: Blockface details

Operating hours	8AM-8PM Mon-Sat
Number of sensors	2
Rate	2

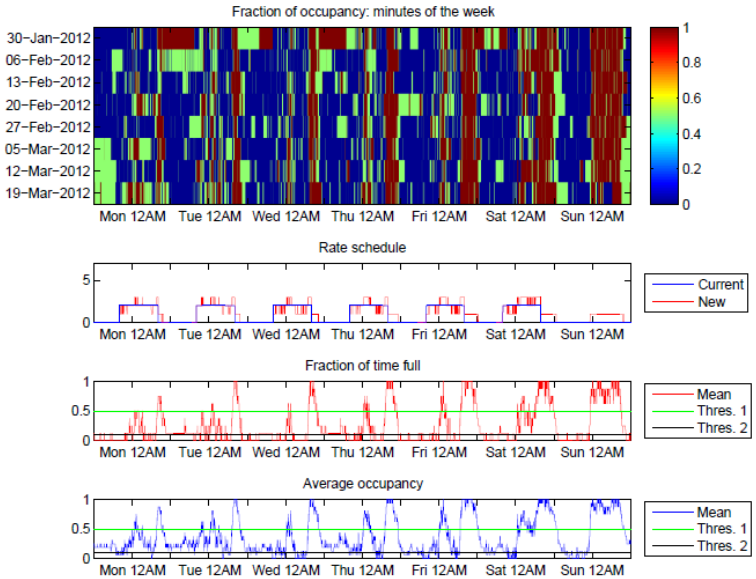


Figure 399: Week view of blockface 500 E 3RD ST

ckface details
AM-7PM Mon-Sat
7
1

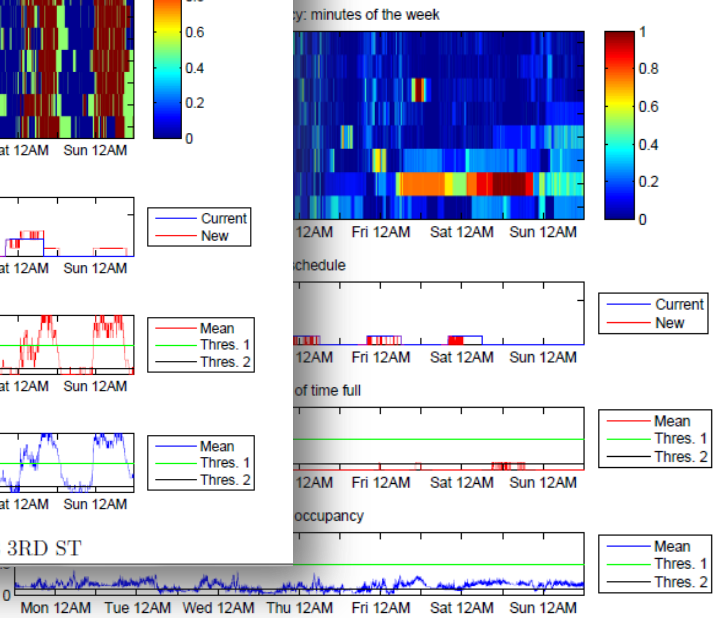


Figure 367: Week view of blockface 400 W 18TH ST

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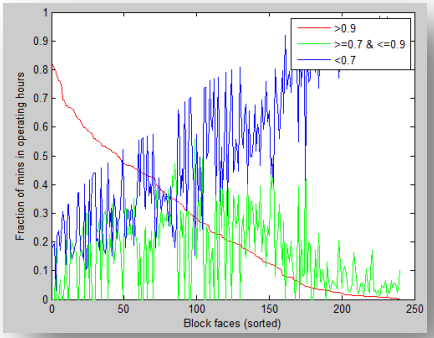
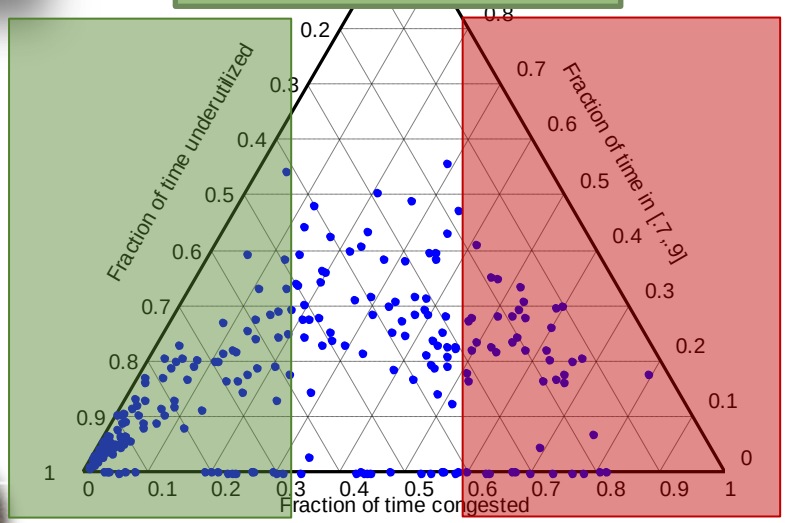
A pricing engine

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]

Don't change the rates here:
Hardly ever too full,
Hardly ever too empty.



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

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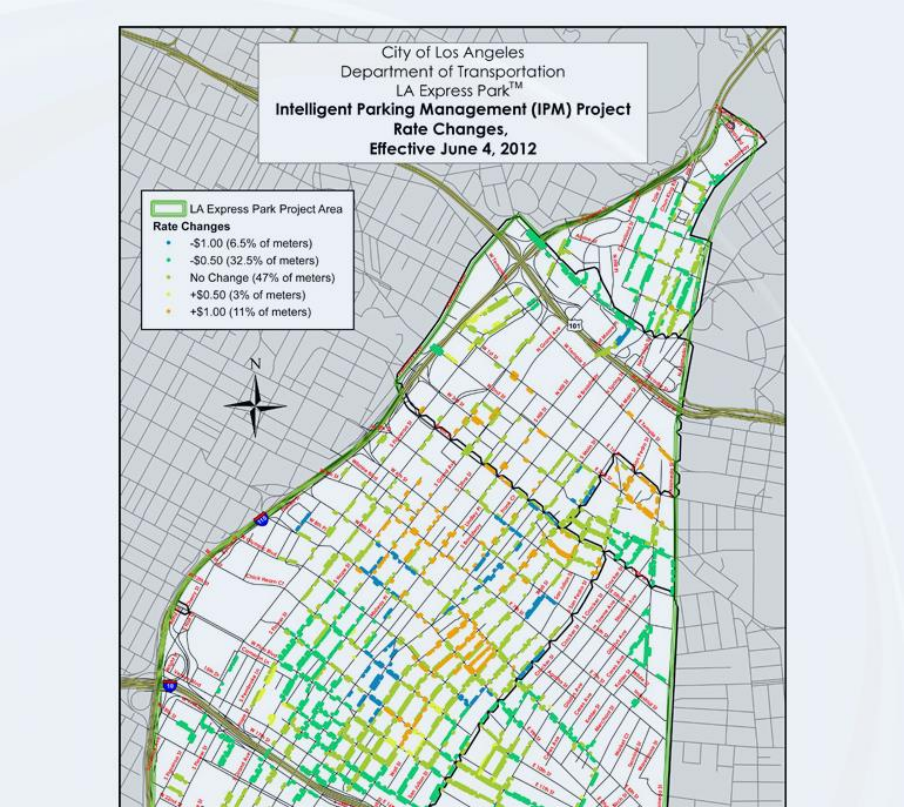
First changes went into effect June 4th 2012



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.

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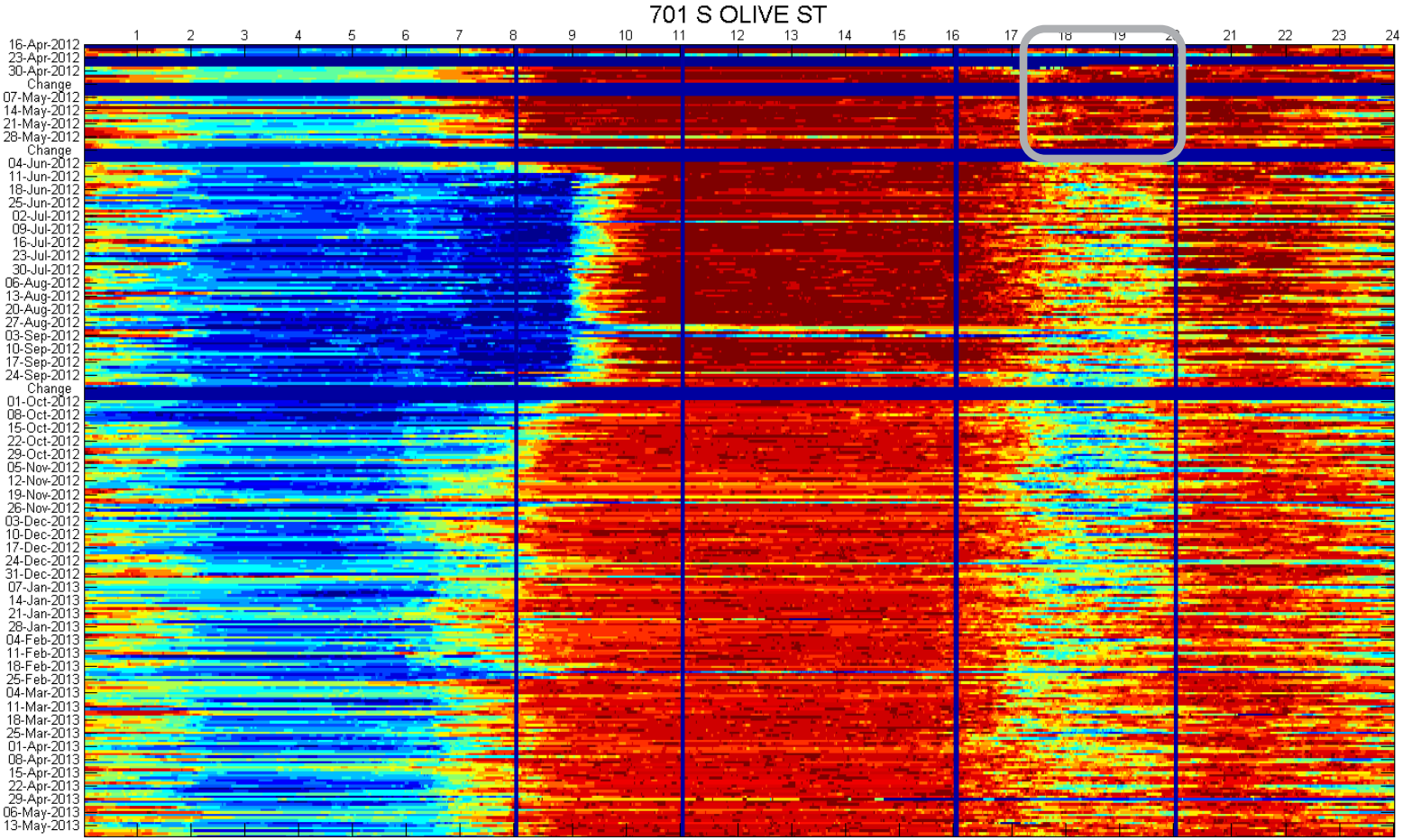
Do people change behaviour?



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Change in behaviour after June 2012 change

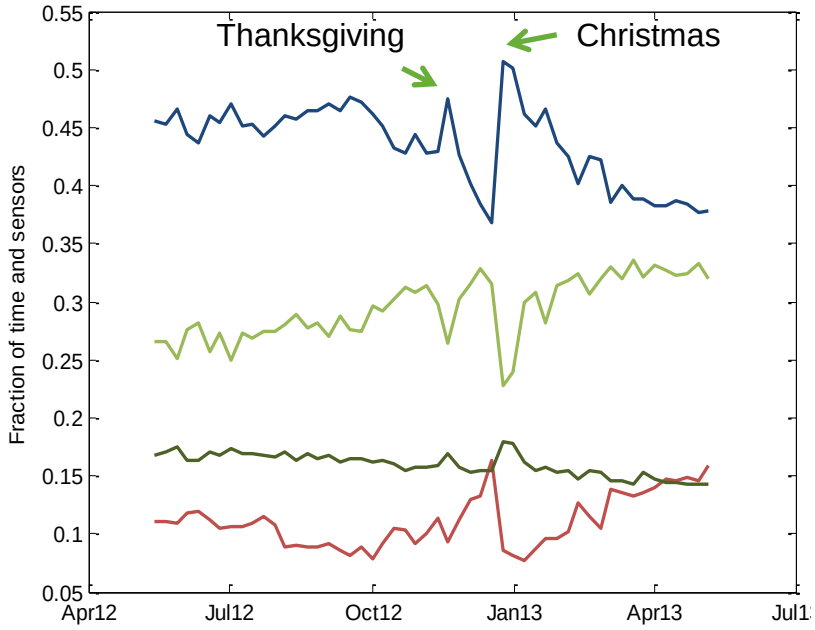
Four situations:

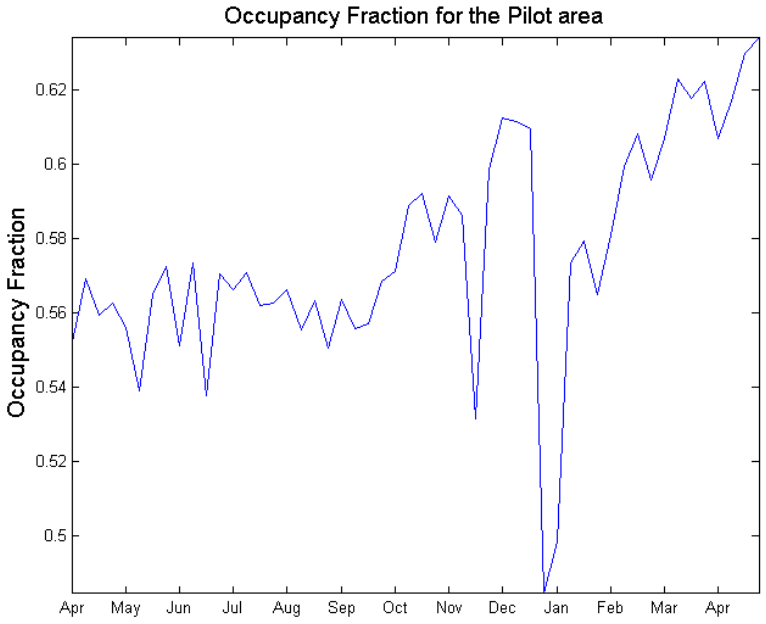
Just-right (Goldilocks)

Not scarce: always enough parking and essentially free

Congested

Under-utilized, yet non-negligible charge





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Questions?

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