ParkNet

Drive-by Sensing of Road-Side Parking Statistics

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What is ParkNet?

- **ParkNet is a mobile system comprising vehicles that collect parking space occupancy information while driving by.**

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Motivation

- **Challenging to obtain real-time street-parking availability statistics.**
- **Traffic congestion is costly.**
  - **costs billions of dollars in the United States alone**
- **Congestion and delays are largely due to parking.**
- **No data available for roadside parking.**

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Usages

- **Improve traveler decisions**
  - **suggest parking spaces.**
- **Dynamic parking space pricing**
  - **price changes based on slots available.**
- **Assist parking enforcement**

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Setup

Each car gathering data has the following:

- **Ultrasonic Sensor**
  - distance to car
  - availability increasing
  - potential for reuse
- **PS3 webcam**
  - evaluation, analysis and training
- **GPS**
  - coordinates of car
- **Computer, power adapter, and wiring**
  - compute and transmit data

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Setup

- **The system is installed into vehicles which regularly move about the city.**
  - **taxi cabs (used in this paper)**
  - **public buses**
  - **police cars**
- **Easier to install and users don't have to worry about setting it up themselves.**

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Slotted vs. Unslotted

- **Slotted**
  - **fixed size**
  - **one car per slot**

- **Unslotted**
  - **depends on vehicle length**
  - **fire hydrants, no parking**

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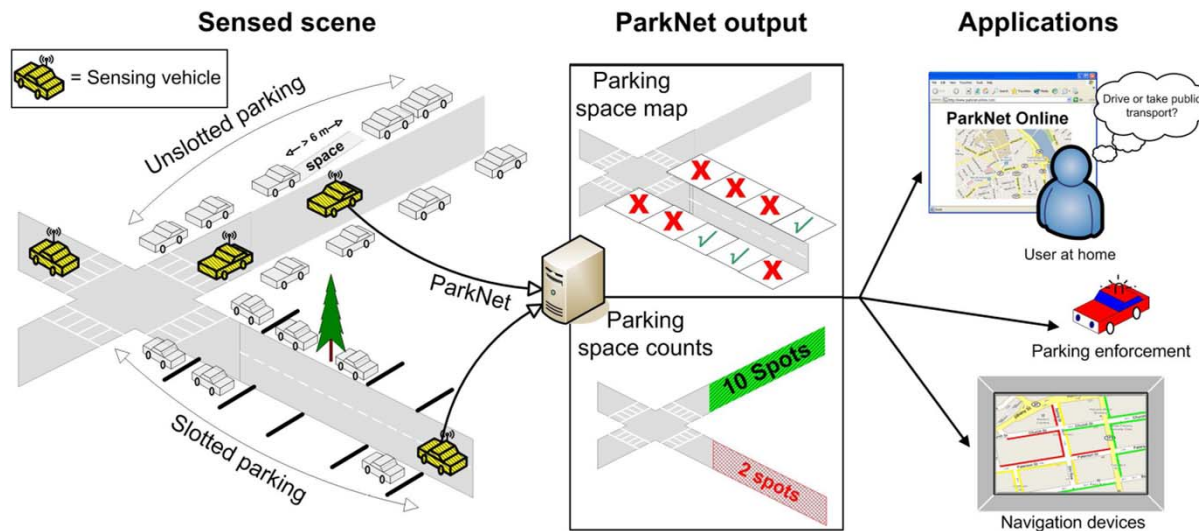
Goals

- **Determine parking availability on an hourly basis.**
- **Helpful to parking enforcement.**
- **Low-cost.**
- **Low vehicle participation.**

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Slotted Algorithm

Width: distance from the start to the end of a dip.

Depth: how far from the baseline a dip extends.

- **Remove dips with too few readings.**
  - can be caused by going too fast
- **Training**
  - get ideal threshold values
  - 19 separate test trips
  - optimal error rate of 12.4%
- **Depth threshold**
- **Width threshold**
  - width greater than 2 thresholds counts as 2 cars.
- **Vacant Spaces = total slots – counted cars**

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Unslotted Algorithm

- **Measure space between parked cars.**
- **See how many cars can fit in that space.**
  - **6 meters per car**
- **Available spots = distance / fixed size (6 meters)**

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Evaluation

- **Used webcam pictures to evaluate accuracy.**
  - **False positives: trees, pedestrians, bikes.**
  - **Misdetection: car is there but not detected.**
- **95% accuracy for parking space counts.**
- **90% accuracy for occupancy maps.**

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GPS Inaccuracy

- **Accuracy for occupancy map must be higher than space count.**
- **GPS inaccuracy can cause spots to be mismatched.**
- **Used environmental fingerprinting to increase accuracy.**
  - fixed objects are location-tagged using the video stills.
  - street needs to be traced multiple times so fingerprinting takes more effort.
- **Position corrected using the Hungarian algorithm.**
  - graph optimization algorithm.

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GPS Inaccuracy

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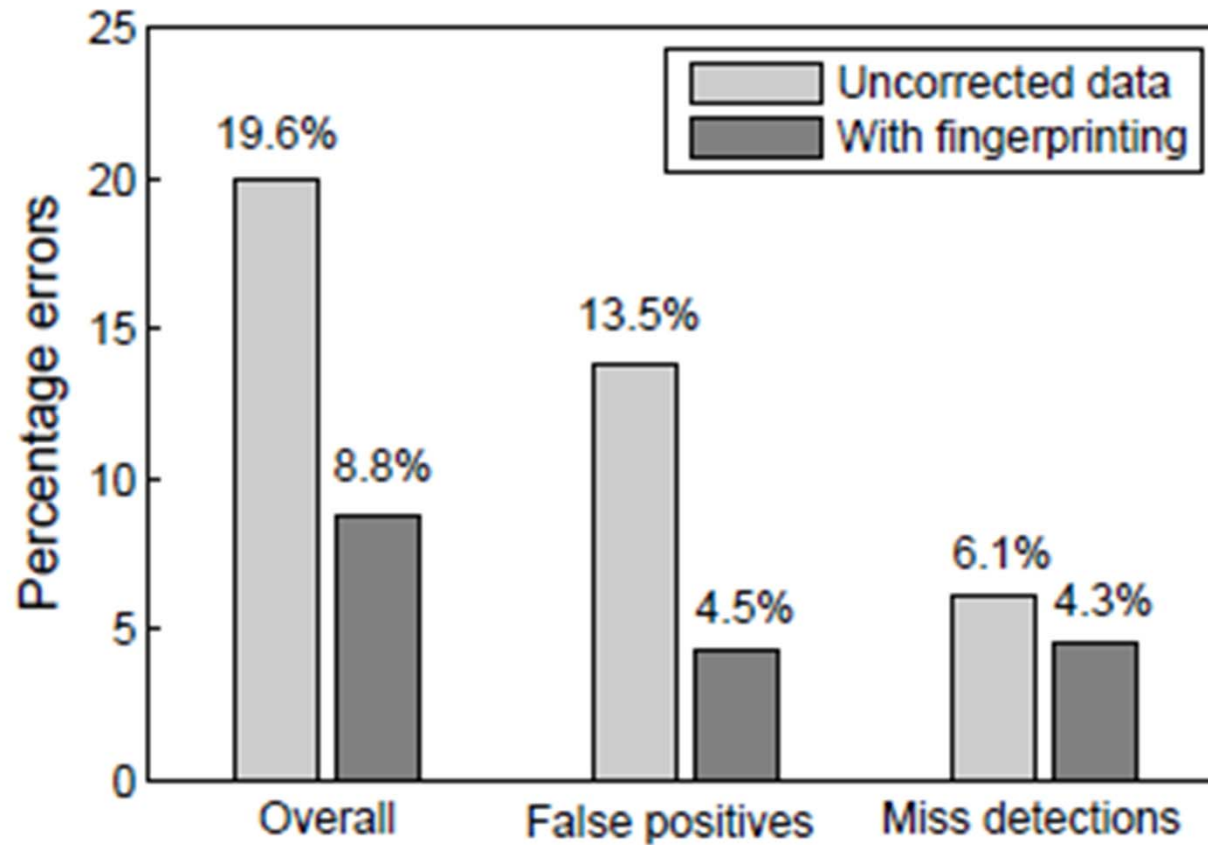
Mobility and Scalability

- **Tracked mobility patterns of 536 taxis in San Francisco over a month.**

- **Greater San Francisco area**
  - **mean time between visits in hundreds of minutes.**

- **Downtown**
  - **mean time less than 10 minutes.**

- **Most parking is in areas with many taxis.**

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ParkNet vs Fixed Parking

Fixed Parking: monitor each slotted parking space individually.

- **SFPark**
  - **6000 parking spaces**
  - **currently being employed in San Francisco**

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Cost

- **~$400 for each sensing vehicle.**
  - **$250-$800 for the smart parking system**
- **~$120,000 for a given area in San Francisco.**
  - **$1.5 million for the smart parking system.**
- **One vehicle can cover multiple parking spots.**
  - **Need a sensor for each fixed parking spot.**

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Maintenance

- **ParkNet is easy to maintain,**
    - can be maintained when taxis go in for maintenance.
    - cities offer many free WiFi spots.
- **Each fixed parking spot must be maintained separately.**

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Disadvantages

- **Parking spot is not guaranteed to be up to date.**
  - **fixed parking sensors are always up to date.**
- **Greater coverage, but random.**

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Unresolved Issues

- **Multilane Roads**
  - only tested on single lane roads.
  - car driving next to sensing vehicle.
- **Speed Limitations**
  - high speed leads to misdetections.
  - parking areas usually have lower speed limits.
- **Obtaining maps**
  - time-dependent spots
  - manual construction from satellite pictures
  - possible to automatically generate

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Related Works

- **Parking garages with counters.**
  - **not displayed on the internet.**
- **Airports and train stations**
- **Buying and selling parking spaces.**
- **Reserved parking spaces.**
- **Pothole detection.**

Results and Contributions

- **Their prototype was a success in obtaining real-time street-parking statistics.**
  - Accurate
  - Low Cost
  - Scalable
  - Useful
- **Useful even with a slight error rate.**
  - don't need to know exact number of available slots.

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Future Work

- **Use the webcam as part of the system.**
  - computer vision algorithms can help detect cars.
  - solution to lane detection?
  - give users images of the parking spaces.
- **Prediction base on statistics.**
  - data gathered over time can be used to predict parking space availability in the future.
  - useful for long-term planning.

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