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Intelligent Parking Assist

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PARKING in a crowded city is characterized by

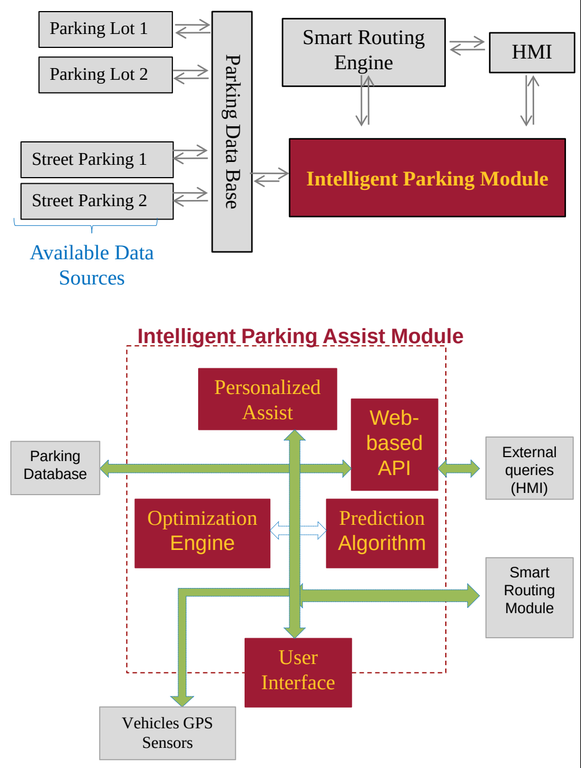
- Frustration
- Waste of time
- Additional pollution and fuel
- Contribution to traffic congestion
- Parking violations and fines

Developed the Intelligent Parking Assist system as part of Audi Urban Intelligent Assist Project:

- Learn driver's preferences based on her past behavior
- Get all available real-time parking data around destination
- Predict parking availability at the estimated arrival time
- Find best available option for the specific driver
- Routing directions to the best parking location
- Reserve parking spots

System Structure

- Parking sensors are placed under on-street parking locations by various agencies.
- Parking garages report the occupancy information
- All the parking data aggregated on USC's database by PATH through a UDL interface.
- Developed a software to track vehicles and store their location on database
- IPA module gets information from databases and process them
- The results are sent back to HMI
- The IPA system runs on an automatic basis until driver reaches her destination.
- Cars communicate to the server through the 4G network.



Personalized Assist - Learning

- Driver's choices and behavior are saved automatically on a USC database for each individual driver.
- Drivers may initially input to the system general parking preferences
- Parking module has a learning algorithm for driver's past selections and destinations.
- Predict the parking preferences based on the type of destination or driver's schedule
- Given initial preferences and learned behavior the system will narrow down to fewer parking options in order to reduce driver workload.

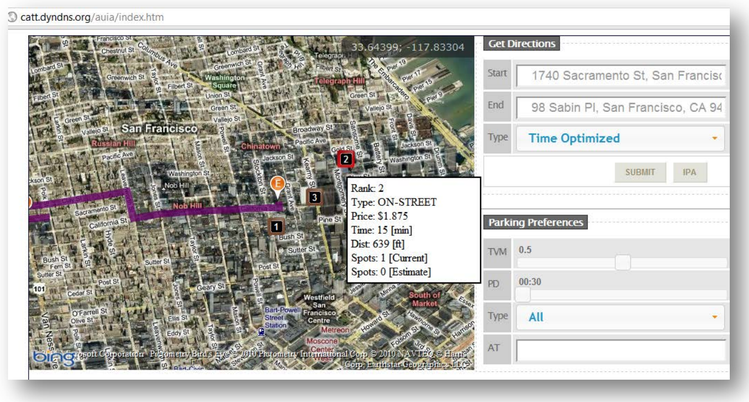
The idea is to decrease distractions and make driving less stressful in urban environments.

Optimization

- Formulate an optimization problem based on:
  - Driver preferences
  - Dynamic Traffic conditions
  - Dynamic Parking availability
- Driver's preferences:
  - Price
  - Walking distance
  - Travel time
  - Travel distance
  - Parking type(reserve, valet, on-street, …)
- Choose optimum solution and update dynamically
- Time-varying parking rules driver's obligations are the constraints
- Cost of the parking is calculated based on approximate parking duration
- Walking distances are calculated as the distance between available spots and actual destination
- Travel times are the estimated travel times from the location of vehicles to available parking spots
- Coefficients of the cost function are determined based on each driver's preferences

Implementation

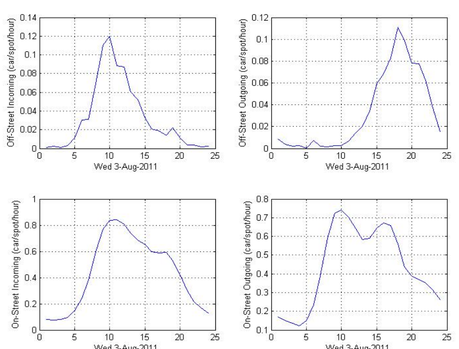
- The Intelligent Parking Assist system is implemented on USC servers and an Audi car
- A website is created as the project's temporary interface:



- IPA is now being tested in Downtown Los Angeles and Downtown San Francisco with real-time parking availability, limitations, and pricing data.

Parking Availability Prediction

- Parking availability cannot be guaranteed at the arrival time.
- We need a mathematic model to estimate available parking spots in Future.
- We gather historic parking availability data and store them,
- extract parking availability models for different times of the day and days of the week.



•Pearson's Chi-Square goodness of fit test method is used:

$$\chi^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i}$$

•Parking Availability is typically a Nonhomogeneous Poisson Process:

$$P\{N_i = n\} = \frac{e^{-\int_0^T \lambda_i(t)dt} \int_0^T \lambda_i(t)dt}{n!}$$

$$P\{N_o = n\} = \frac{e^{-\int_0^T \lambda_o(t)dt} \int_0^T \lambda_o(t)dt}{n!}$$

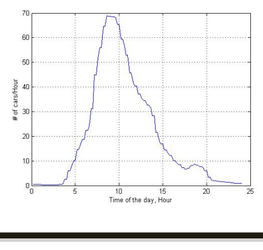
Where N_i and N_o represent the number of incoming and outgoing cars to a parking facility.

•The mean value of the distribution can be estimated to be constant for one hour periods.

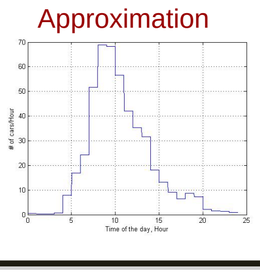
•The first diagram shows the number of cars which are entering a particular parking structure for different times of the day

•Second diagram Shows an approximation for 1 hour periods.

Actual:



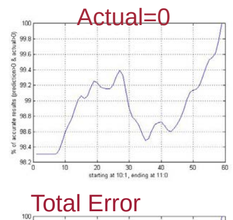
Approximation



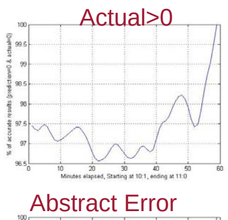
•The probability model is used to predict the number of available parking spots at the estimated arrival time.

•Evaluation of prediction algorithm based on real availability data for San Francisco Fisherman's Wharf area:

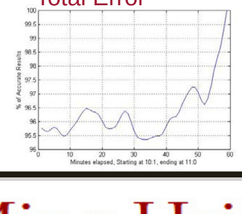
ERROR: Predicted>0 Actual=0



ERROR: Predicted=0 Actual>0



Total Error



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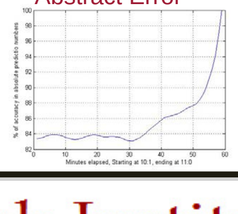

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