Intelligent Parking Assist
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PARKING in a crowded city is characterized by:
- Frustration
- Contribution to traffic congestion
- Waste of time
- Parking violations and fines
- Additional pollution and fuel

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

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

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.

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 mathematical 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:
  \[ \chi^2 = \sum \frac{(O_i - E_i)^2}{E_i} \]
- Parking Availability is typically a Nonhomogeneous Poisson Process:
  \[
  P(N_t = n) = \frac{e^{-\lambda(t)}(\lambda(t))^n}{n!}
  \]
  \[
  P(K_t = n) = \frac{e^{-\mu(t)}(\mu(t))^n}{n!}
  \]
  Where \( N_t \) and \( K_t \) 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.

- 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.