Visualization of Surface Parking Lots

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Motivation

- Drivers can waste a considerable amount time and fuel searching for parking spots.
- Goal is to train a neural network to classify parking spaces in a surface lot as either occupied or empty.
- Benefits include reduced commute time and emissions, fuel savings and boost in productivity.

Data set

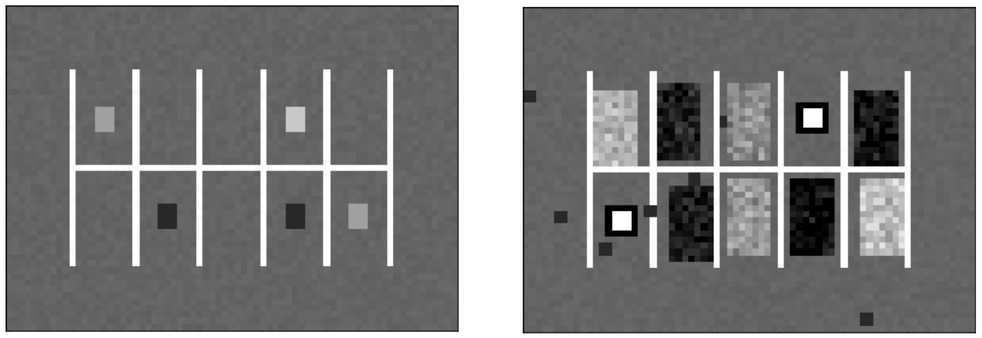
- Simple computer generated surface lots (grayscale)
  - Small parking lot = 51 x 71 (10 spaces)
  - Large parking lot = 101 x 171 (60 spaces)
- Training data = 100,000 images
  - Empty parking lot with randomly tagged spaces (4 colors)
  - FCN tags = 4 x 3
  - CNN tags = 12 x 7
- Test data = 1000 images per number of parked cars
  - Randomly occupied surface lots
  - Add small gaussian noise to background
  - Cars have 12 colors + gaussian noise
  - Car positions randomly shifted
  - Scattered people = 2 x 2 (dark gray)

Methods

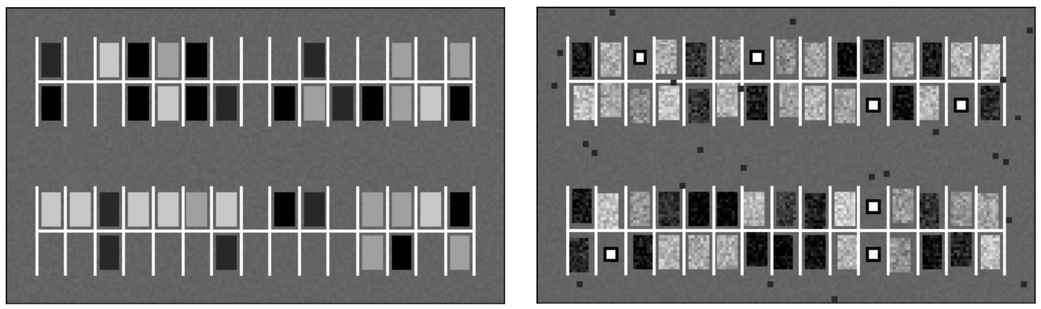
1) One-layer fully connected network (FCN)
   - Hidden layer = 120 nodes

2) Eight-layer convolutional neural network (CNN)
   - Convolution kernel = 16 x (4 x 4)
   - Max pooling = 2 x 2

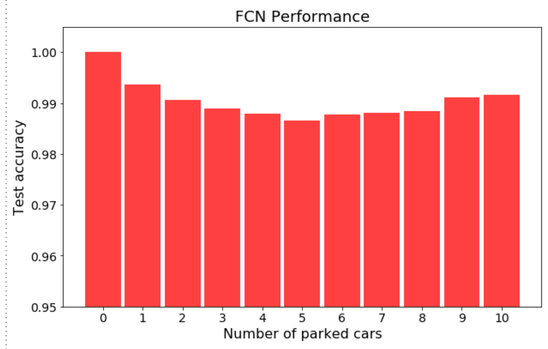
- Output layer = 10 or 60 nodes
- Training label = tags' occupancy positions
- Optimizer = stochastic gradient descent
- Loss = binary cross-entropy

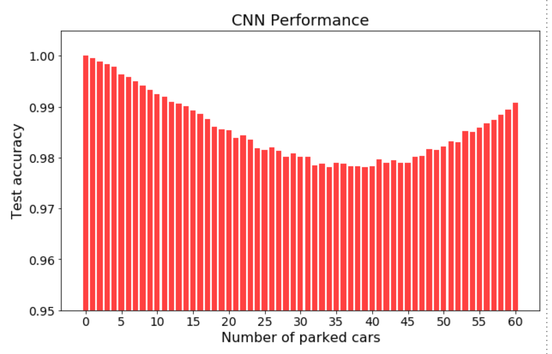


FCN network trained on small tagged parking lots (left) and example test prediction (right).



CNN network trained on large tagged parking lots (left) and example test prediction (right).





Performance of FCN on small parking lots (left) and CNN on large parking lots (right).

FCN Results

- Average test accuracy = 99%
- Why does this work?
  - Network focuses on center of parking spaces and ignores other features.
  - Parked cars will most likely overlap these tagged areas.
  - Generalizes to imperfect parking and people in the lot.
- Difficult to scale model for larger images.

CNN Results

- Average test accuracy = 98.5%
- Why does this work?
  - Network learns tags' edge and corner features.
  - Insensitive to imperfect parking and lighting variations on car.
- More suitable for large parking lots than FCN model.
- Accuracy has minimum for half-filled parking lot.

Conclusions and Outlook

- Developed two different neural networks that can accurately classify empty parking spaces in grayscale surface lots.
- Both networks have difficulty identifying gray cars.
- Train networks on more realistic surface lot images
  - Computer generated colored surface lots.
  - Add cars in the alleys.
  - Add lighting variations during the day + night.
  - Real satellite images.
- Implement network in mobile applications.

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