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Scalable real-time parking lot classification: An evaluation of image features and supervised learning algorithms

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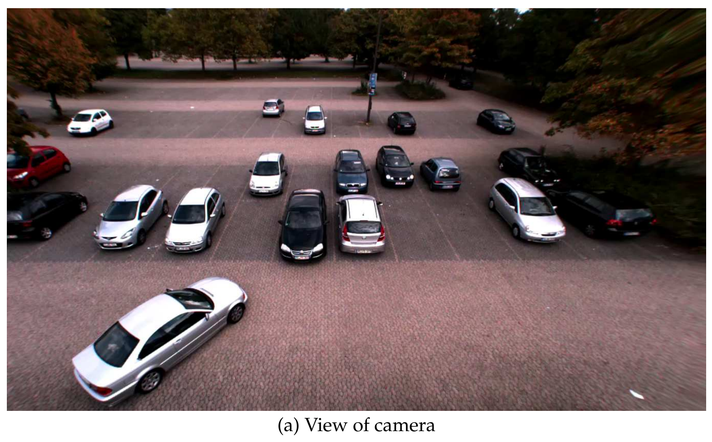


(a) View of camera

(b) Rectified ROIs from video image

(c) Classification of occupied (red) and vacant (green) parking lots of the proposed system

Motivation

- Finding vacant parking lot time-consuming and tedious task
- Navigating drivers to proper lots is desirable
- Usual approach: Sensors at each lot (cost-intensive) or counting cars at entrance (no detailed occupancy map)

→ Video-based system using image features and supervised learning algorithms which is highly scalable

System

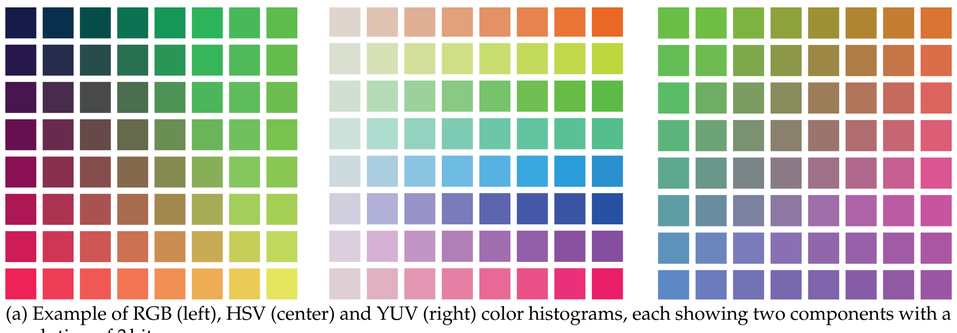
- Standard desktop PC (laptop with Intel Core i5-3210M Processor and 6 GB working memory running Microsoft Windows 7)
- Off-the-shelf camera with wide-angle lens
- Top view of 7.5 m height, observing 36 lots in three different rows

Method

- Calibrate lens distortion and transformation to ground plane
- Mark parking lots in ground plane image
- Extract image features for each parking lot image
- Classify parking lots
- Visualize results

Image features

- Color histograms
- *DoG*-feature histograms



(a) Example of RGB (left), HSV (center) and YUV (right) color histograms, each showing two components with a resolution of 3 bits.

Supervised learning algorithms

- *K*-nearest neighbour (*k*-NN)
- Linear discriminant analysis for linear classifier (LDA)
- Support vector machine (SVM)

Experiments

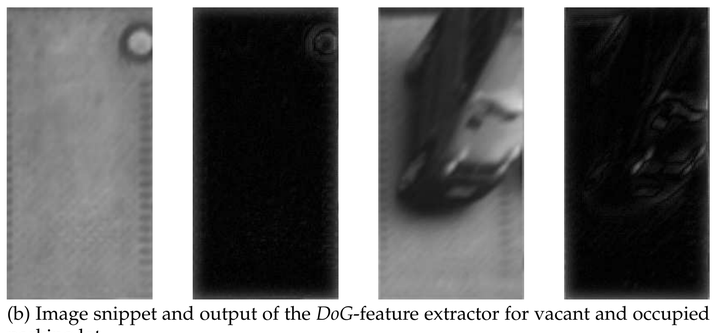
- Scenarios:
  1. Parking area “ID”, sunny
  2. Parking area “ID”, different lighting conditions, foggy
  3. Parking area “FH”, typical autumn day
- Datasets:
  - Training: 5,000 snippets from scenario 1
  - Test: 5,000 snippets from scenario 2
  - Validation: Full sequence (2.5min) from scenario 3
- Each feature / learning algorithm combination trained and tested

Results

- Final system: DoG features (filter size 9 × 9), SVM classifier, temporal smoothing
- Installed at untrained parking area, accuracy of 99.96 %
- Third parking row still classified with accuracy of 92.33 %

Outlook

- Minimizing influences of cars parking left or right (3D estimation)
- Using embedded hardware to enlarge the monitored area
- Building a system which navigates to proper lots (tracking and routing of cars)



(b) Image snippet and output of the *DoG*-feature extractor for vacant and occupied parking lot