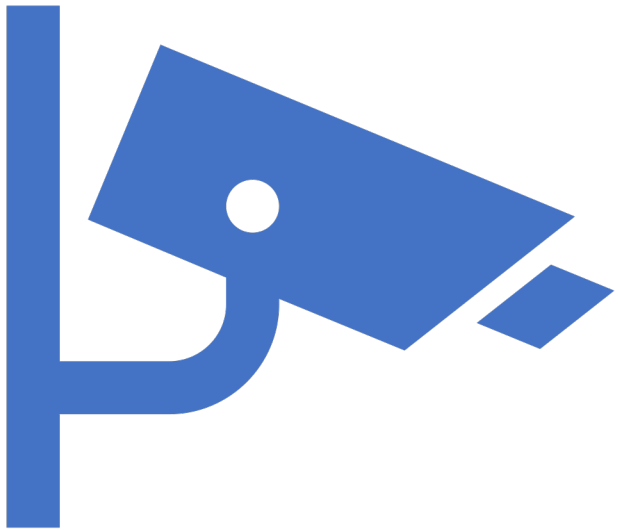

Monitoring Cleanliness of Public Transportation with Computer Vision

Risto Ojala, Tuomas Kinnunen, Joel Mattila, Mikael Aakko, Panu Kiviluoma and Petri Kuosmanen

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Motivation and Goal

- Cleanliness has an immense impact on passenger comfort in public transportation
- With driverless public transport in the near future, a method for surveilling cleanliness of the vehicles is required
- We present a computer vision solution for detecting litter in public transportation vehicles

Picture: https://commons.wikimedia.org/wiki/File:MTA_NYC_Subway_R62A_interior.jpg

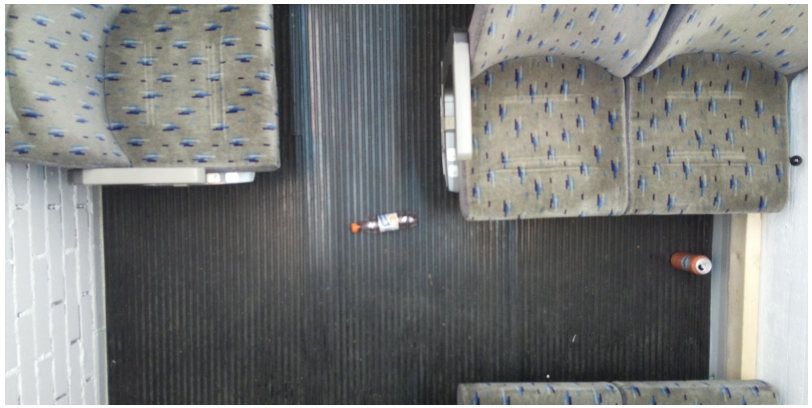
Test Environment

- Test environment was constructed in a laboratory using ten bus seats
- Four LED strips were installed to provide variable lighting
  - Two warm strips (6000 K)
  - Two cold strips (3000 K)
- The variable lighting allows development and testing of robust algorithms

Camera Set-up

- Two different camera set-ups
  - Linearly actuated camera
  - Stationary camera
- Linearly actuated camera allowed capturing more image data per litter arrangement

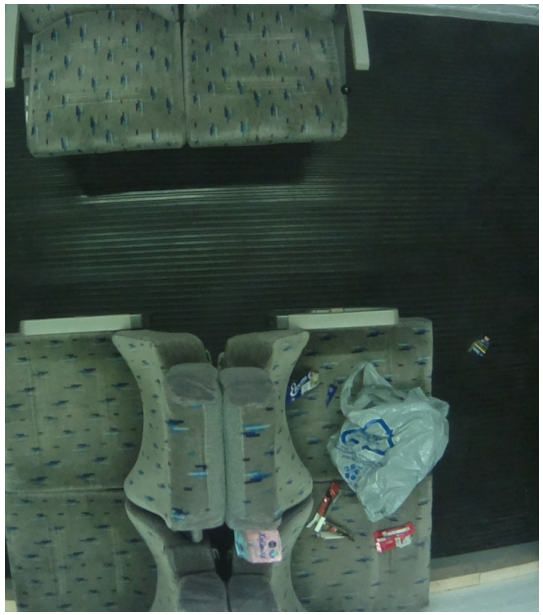
Type	Linear	Stationary Wide-lens
Resolution	8 MP	5 MP
FoV vertical	48.8°	119°
FoV horizontal	62.2°	132°

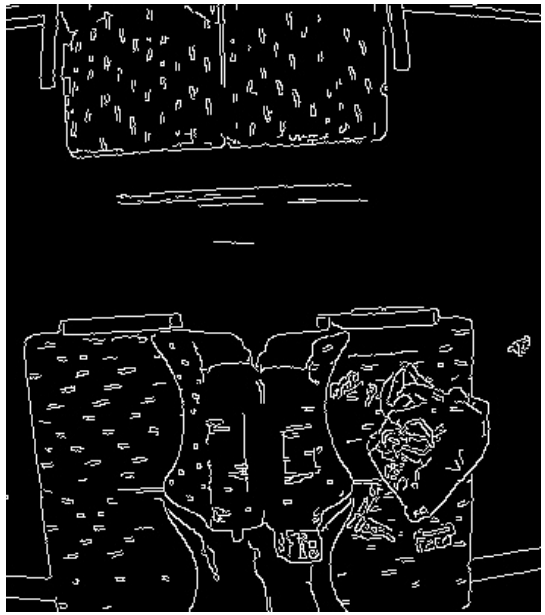


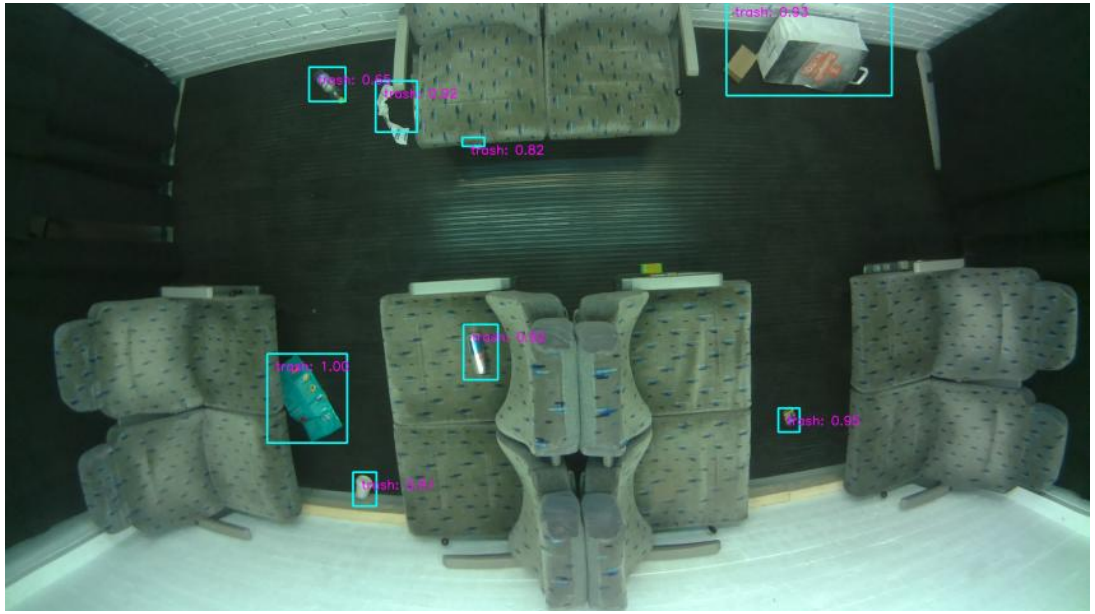
How Image Data Was Gathered

- Linear rail cam at three to five positions
- Lights: Six settings
  - changes brightness, color, shadows and reflections

- Total number of images:
  - Linear camera 932, wide-lens 310, total 1242
- Approximately 40 unique trash objects used in 42 different arrangements with 5.3 trash on average
- Captured images sent to a remote server





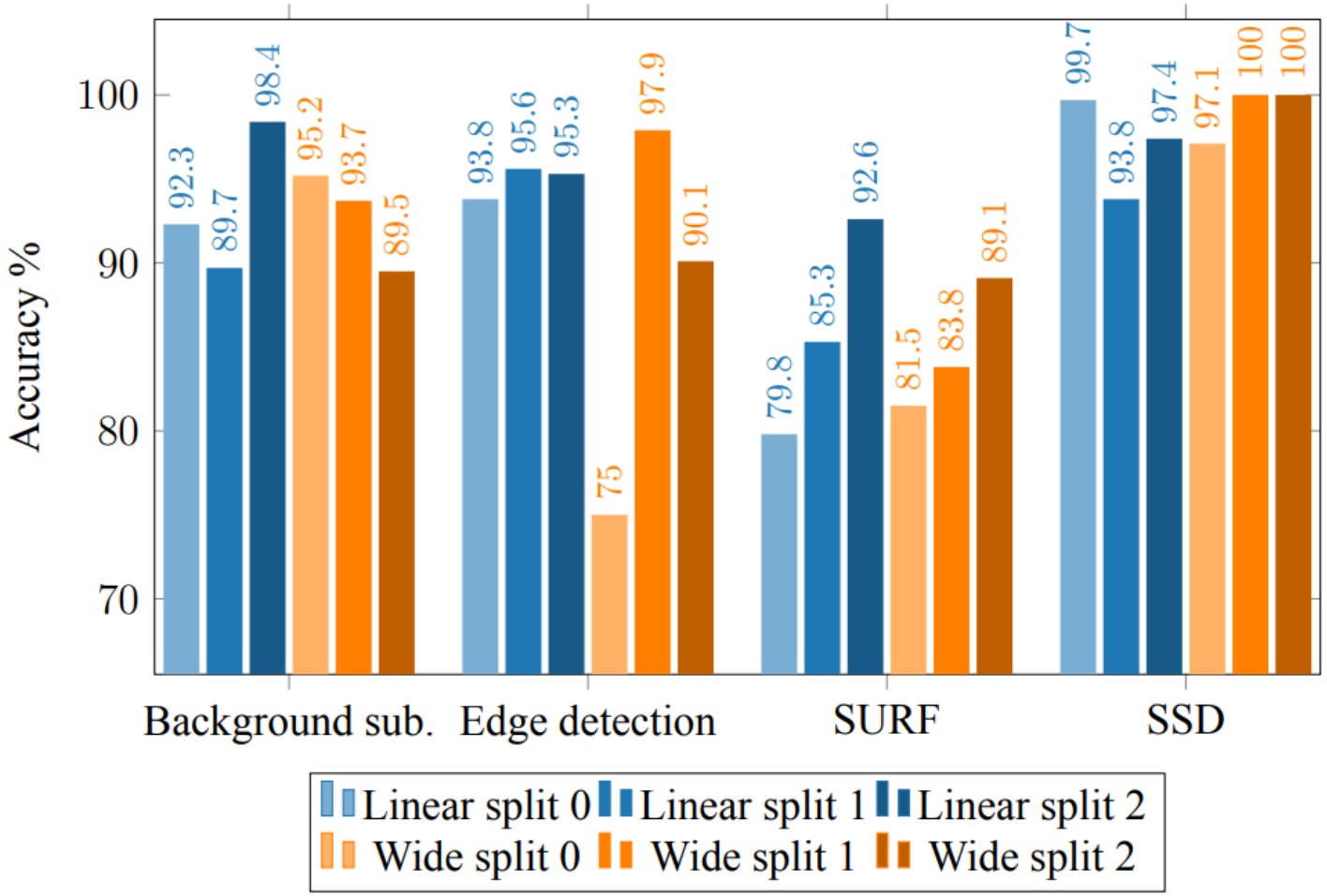


Algorithms

Four different solutions

1. Background subtraction used for forming a background and detecting objects that do not belong in it
2. Edge detection output fed to a Random forest classifier
3. SURF keypoints with K-means and XGBoost classification
4. SSD convolutional neural network

From top left: normal image, background subtraction, edge detection, SURF keypoints and SSD.



Results

- Accuracies over 90% were acquired.
- Linear and wide-angle units were evaluated separately
- Three unique test datasets for both units
- Linear unit did not provide higher accuracies, but instead showed inconsistency in the results

Discussion

- Accuracy was found suitable for implementation in real public transportation vehicles
- More reliable results and better accuracies would have likely been acquired with more image data
- Development of the units will continue in U-bahn in Hamburg
- Presented system has potential to improve passenger comfort