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Detecting Trash and Valuables with Machine Vision in Passenger Vehicles

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Background

- Increased use of public transportation
  - *Reduce traffic flow*
  - *Reduce vehicle emissions*

- Developing concept of driverless taxis

- Important to maintain good levels of cleanliness

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Background cont..

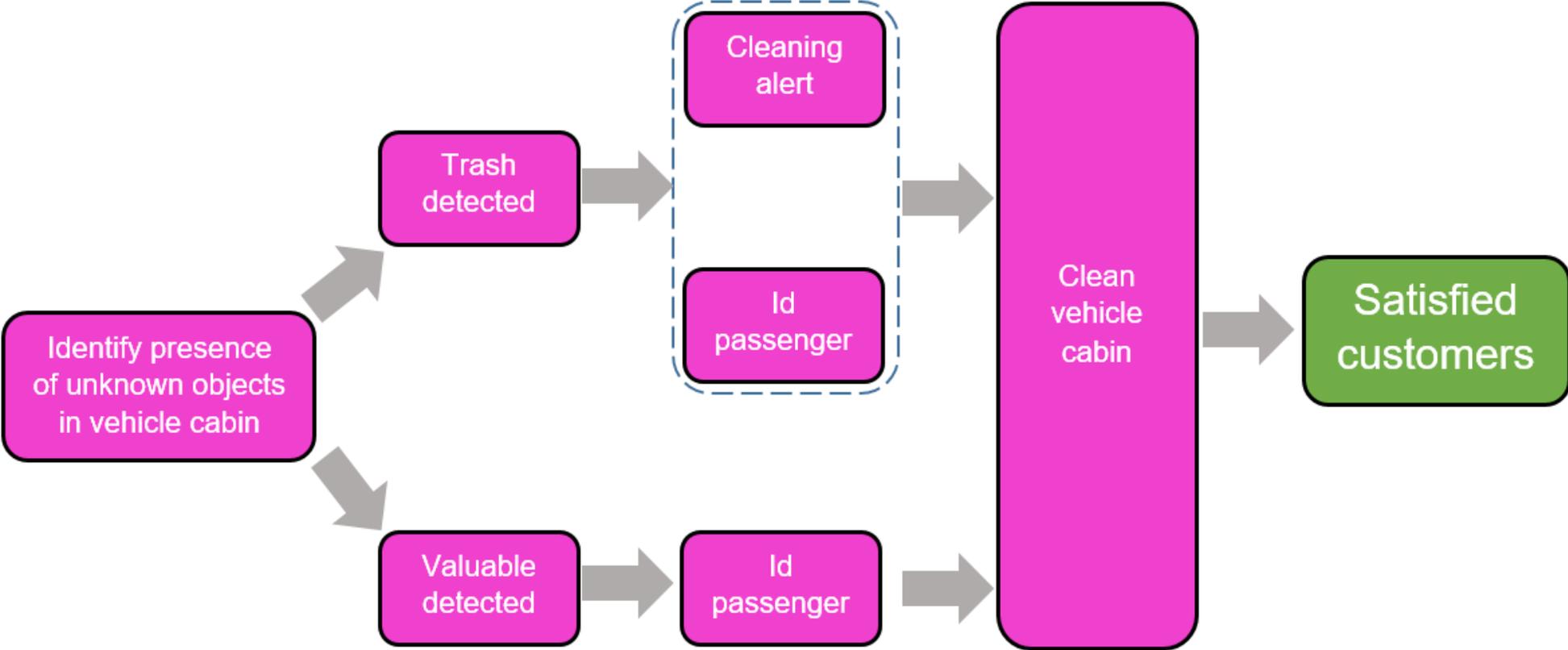**Exterior cleanliness**

Interior cleanliness

Background cont..

- **Research question:**
  - Possibility of detecting trash and valuables in cabins of shared vehicles
  - Vision based application

- **Importance in practice:**
  - Ensure constant good levels of interior cleanliness for prolonged use

Motivation

Objectives

- **In vehicle camera system for shared vehicles**
  - Capture the state of the rear seating compartment

- **Algorithm to classify between:**
  - A clean seat
  - Seat containing trash items
  - Seat containing valuables

- **Compile an image dataset**

Areas of interest

✓ Relevant vision based detection and classification applications

✓ Types of existing models and solutions

✓ Applicable image databases

✓ Interior cleanliness management in automobiles

Trash classification models

"Classification of Trash for Recyclability Status" -Thung and Yang (2016)	• Created an open source trash image database • Two models to classify waste into 1 of 6 categories • Detection accuracies of 63% and 22%
"Intelligent Waste Material Classification System Using Deep Learning Convolutional Neural Network" -Adedeji and Wang (2016)	• Waste classified 1 of 4 categories • Neural Network model • 87% detection accuracy
"Visual Based Trash Detection and Classification System for Smart Trash Bin Robot" -Salimi et al.(2018)	• Traverse public places • Sounds alarm upon detection • Traditional vision-based algorithm (Viola-Jones + SVM) • 82% detection accuracy

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Research Gap

Utilization of a suitable machine vision based algorithmic technique to address the issue of cleanliness and seat occupancy with respect to trash and customer belongings in shared vehicles
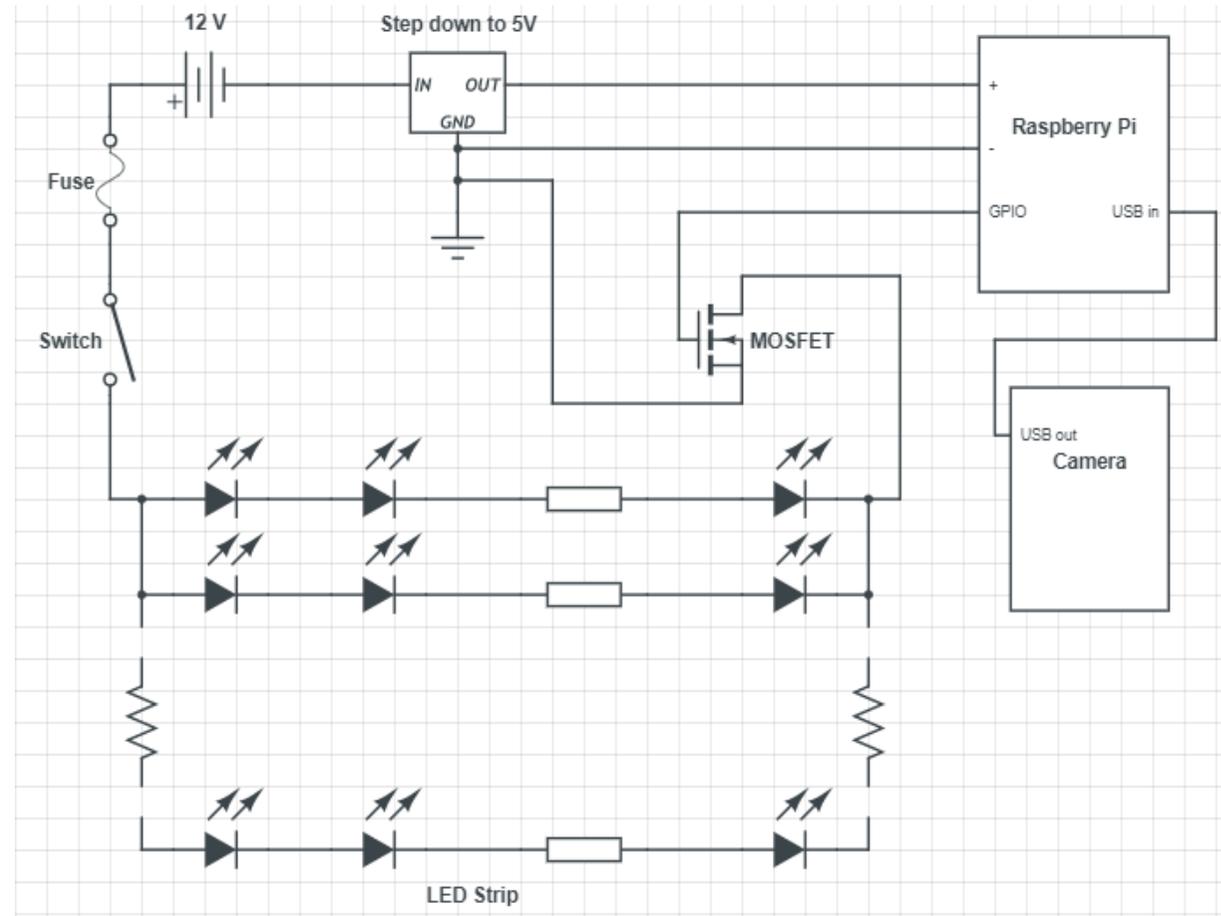
Aalto research vehicle (Ford Focus)

- Model trained on a single vehicle

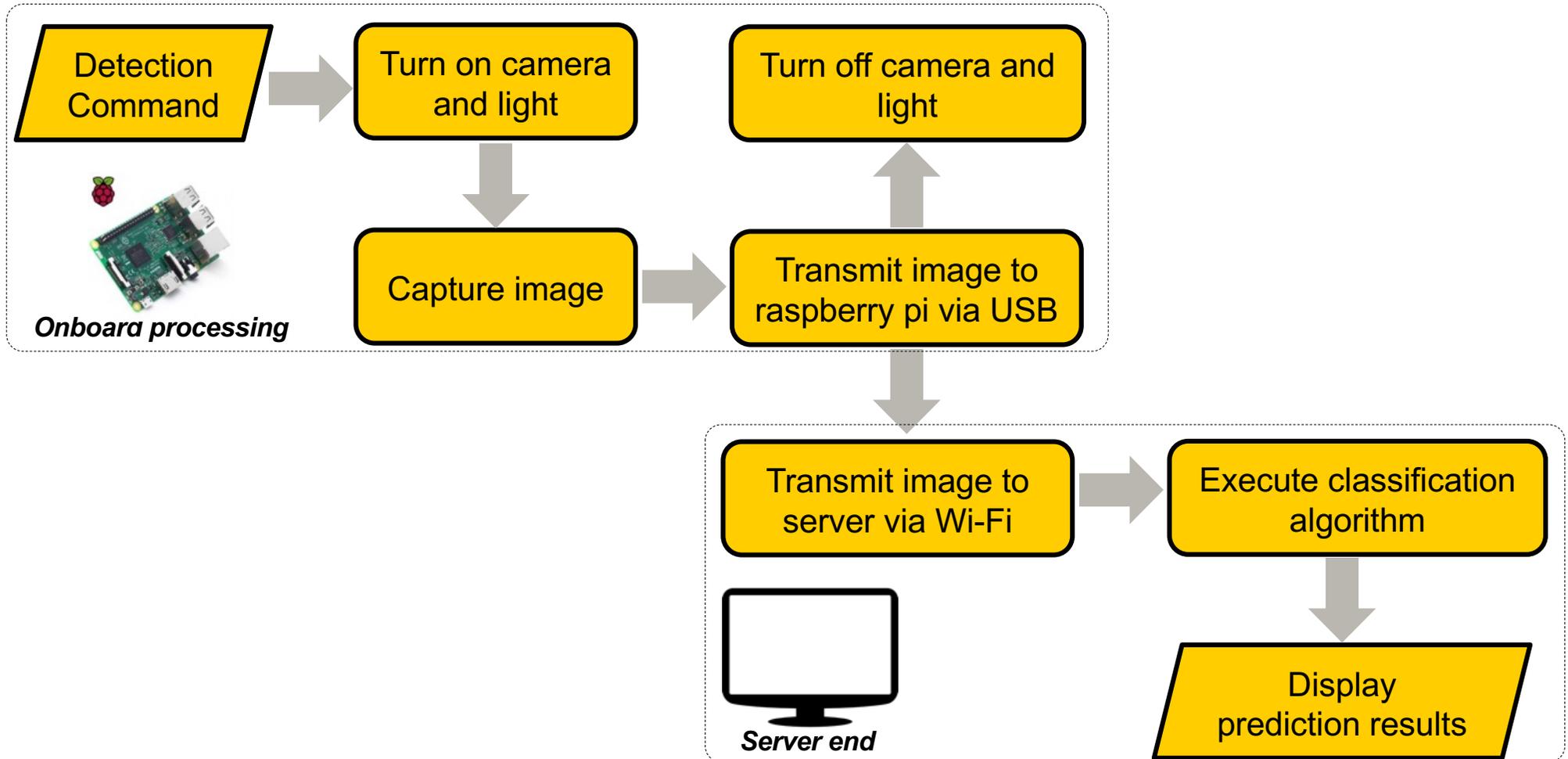- Could be fine-tuned in the future for other models

On-site components and connections

- 12V power supply
- Raspberry Pi (Model B+)
- Fisheye camera
- LED strip
- MOSFET (n channel)

Process flow diagram

Detection Command → Turn on camera and light → Capture image → Transmit image to raspberry pi via USB → Turn off camera and light

Onboard processing

Transmit image to server via Wi-Fi → Execute classification algorithm → Display prediction results

Server end
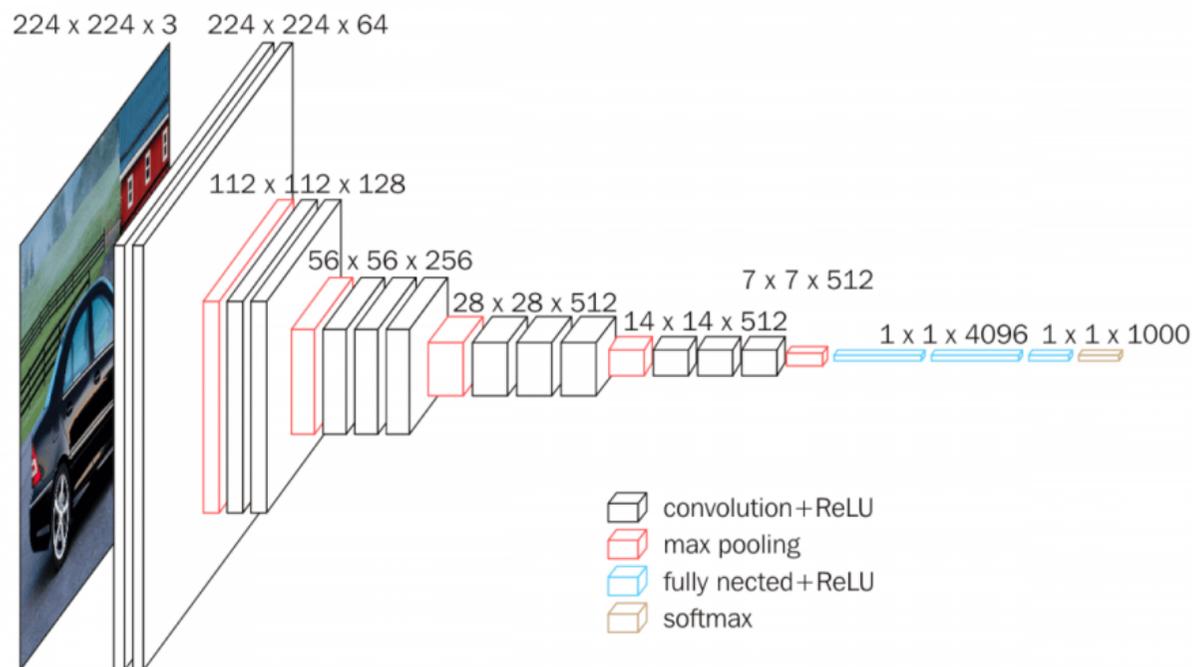
Algorithm

Current scope
- Binary classification: Empty, Not Empty
- Three class classification: Empty, Trash and Valuable

Future work
- Produce a cleanliness level on a scale

Algorithm: **Vgg16 (CNN)**

Architecture

224 x 224 x 3   224 x 224 x 64

112 x 112 x 128

56 x 56 x 256

28 x 28 x 512

14 x 14 x 512

7 x 7 x 512

1 x 1 x 4096 1 x 1 x 1000

- convolution+ReLU
- max pooling
- fully nected+ReLU
- softmax

Primary software and libaries:

- Python
- Keras
- Tensorflow
- OpenCV

Expected output:

- Confusion matrix
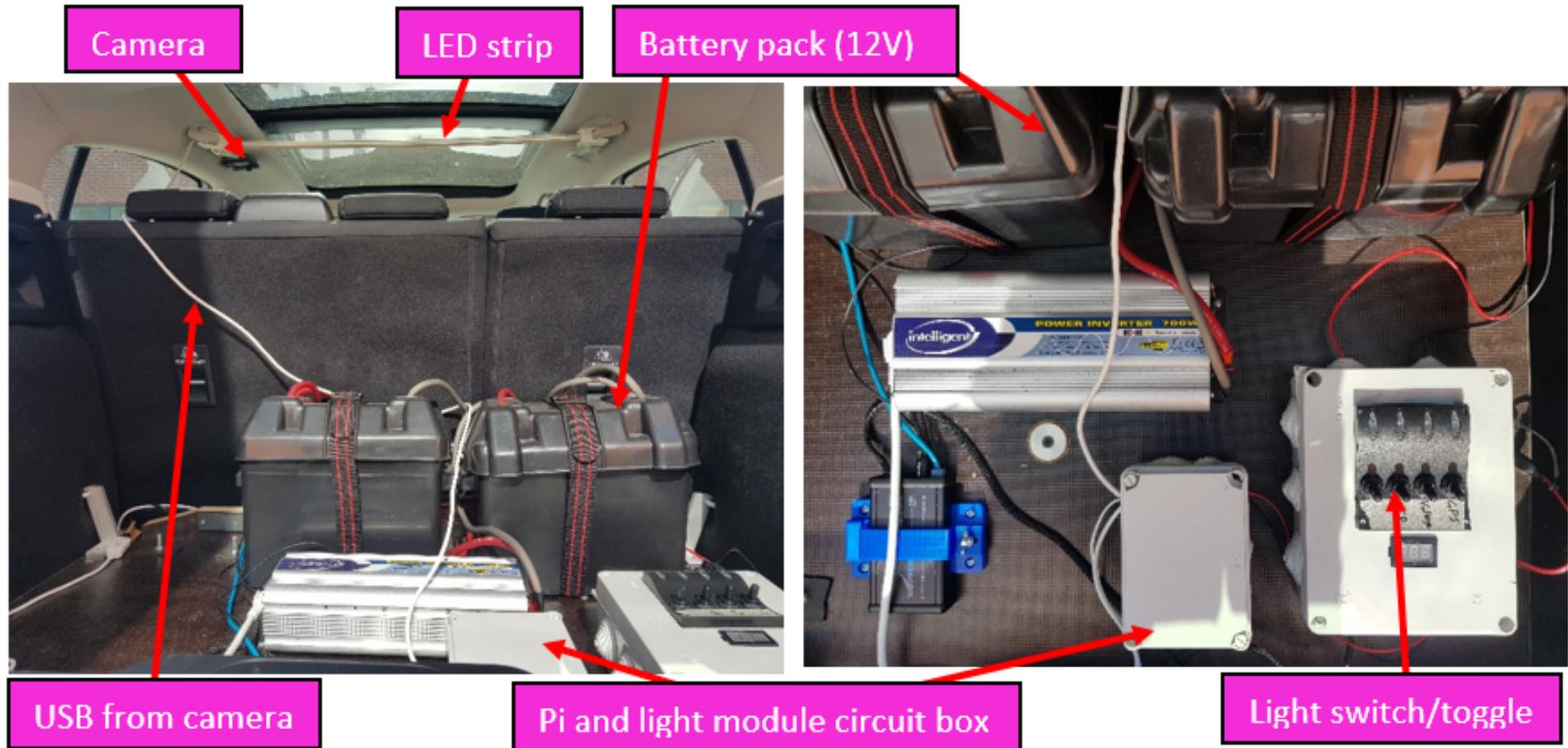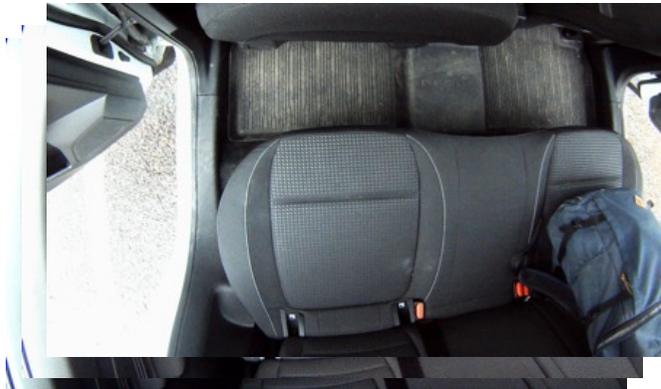- Predicted classes with uncertainties
- False predictions

Actual setup

Image dataset

- 3 categories: Empty, Trash and Valuables

Total: 1164 images

+ image augmentation

2015 images

Types of variation in the images

Shadows

Rear doors

Lighting

Front seat positions

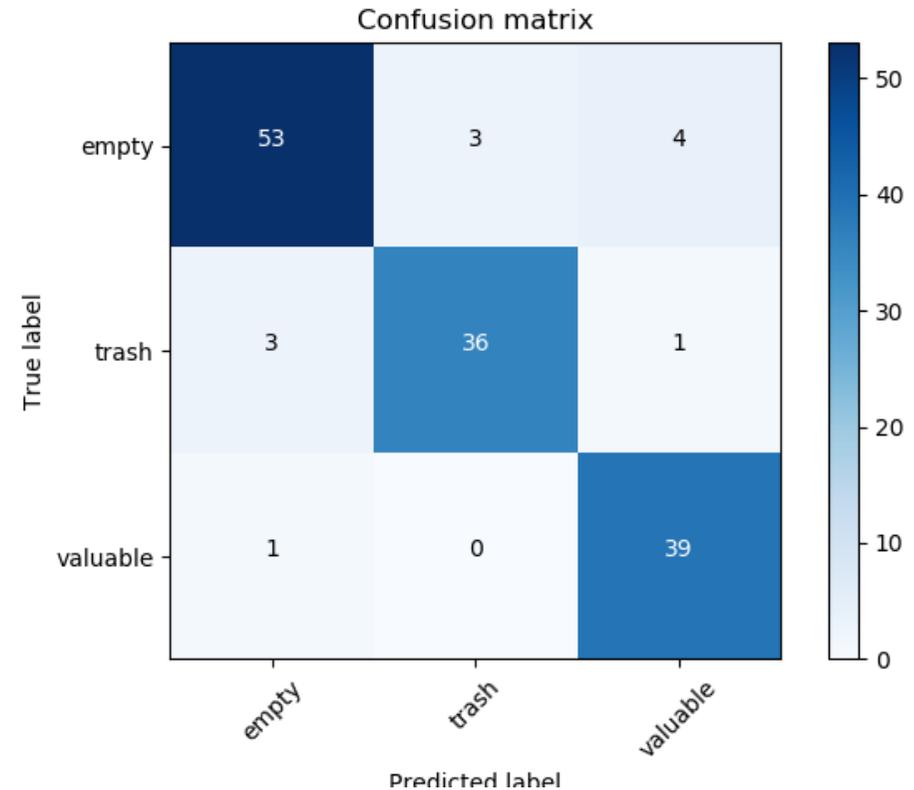# Results of the Vgg16 CNN (test batch)

Total test images: 140
Correct predictions: 128
False predictions: 12

Prediction accuracy: 91.42%

Uncertainties:

Index	Empty	Trash	Valuable
0	0.9550	0.0113	0.0338
1	0.0611	0.0000	0.9388
2	0.2498	0.0003	0.7499
4	0.3206	0.0003	0.6792
5	0.4347	0.5652	0.0001
6	0.0650	0.8861	0.0489
7	0.1853	0.0002	0.8145
8	0.1583	0.0002	0.8415

Confusion matrix

Sample predictions: Clean

Sample predictions: Trash

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Sample predictions: Valuables

False predictions

True class: Valuable
Predicted class: Empty

Reason: Object with glare under bright area

False predictions cont..

True class: Empty
Predicted class: Trash

Reason: Driver's seat
pulled all the way back

False predictions cont..

True class: Valuable
Predicted class: Empty

Reason: Very dark object undetected due to lack of contrast
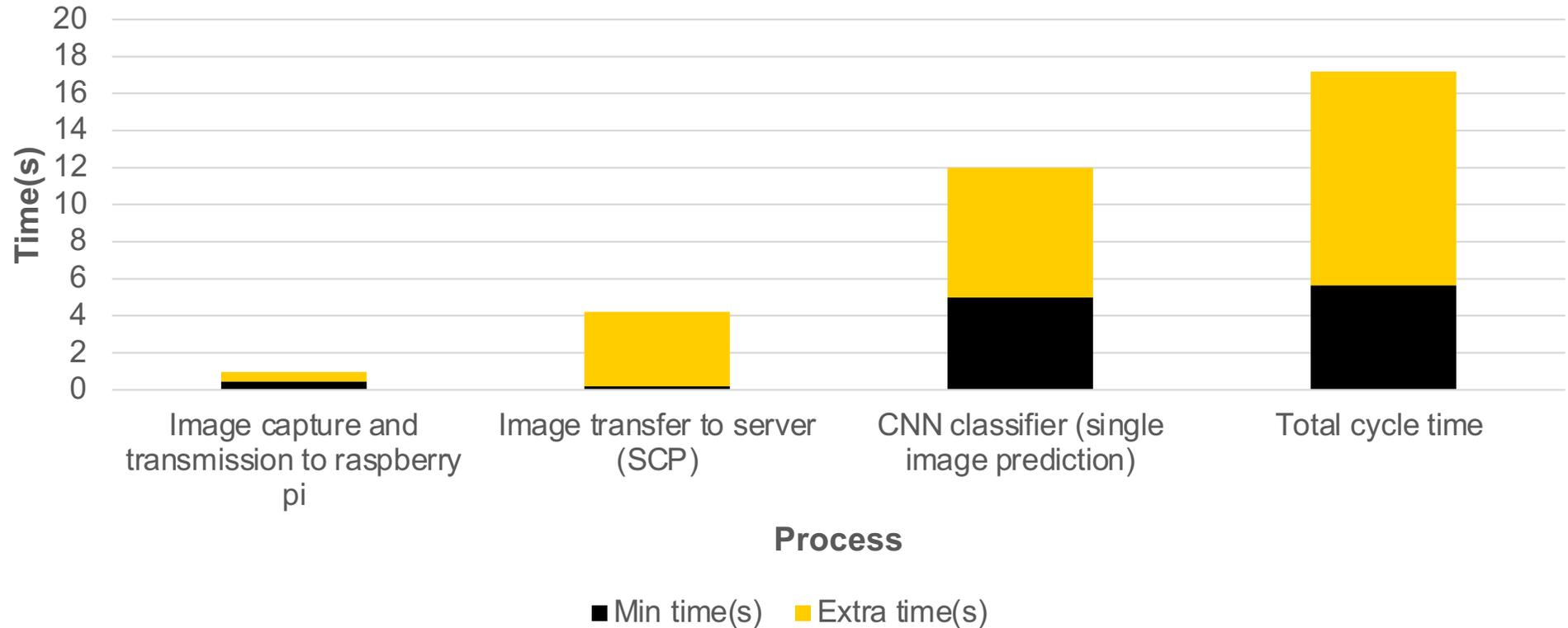
False predictions cont..

True class: Trash
Predicted class: Valuable

Reason: Object detected
but misclassified due to
lack of contrast and
distance from the camera

Cycle time for predicting a single image

Comparison to Previous Studies

PROs

- Specificity of the application in this research
- Unique dataset creation
- Simpler CNN and better tuned
- Detection under more forms of variation

CONs

- Less types of objects in the trash class
- Certain amount of bias in the dataset

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Summary of the Study

- **Research question:**
  - Possibility of detecting trash and valuables in cabins of shared vehicles
  - Vision based application

- Results proved this is possible
- Accuracy does suffer due to external randomness
- Dataset expansion will be required further (night time images)
- Integration into an actual vehicle required to obtain more "natural" data

Future research cont..

- **Algorithm development**

Current scope
- Binary classification: Empty, Not Empty
- Three class classification: Empty, Trash and Valuable

Future work
- Produce a cleanliness level on a scale
- Integration of the vision based detection system with an odor detection module

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Thank you!

Questions are welcome