

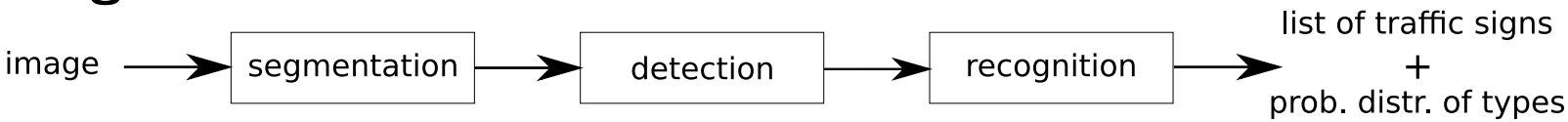
Introduction
Segmentation
Detection
Conclusions

Traffic Signs Detection / Recognition - Proposal and Preliminary Results

October 8, 2008

Overview

Single-view



- **Segmentation** - extremely fast bounding box selection process with $FN \longrightarrow 0$.
  - Traffic signs are designed to be well distinguishable from background $\Rightarrow$ have distinctive colors and shapes.
- **Detection** - AdaBoost classifier of bounding boxes.
- **Recognition** - SVM.

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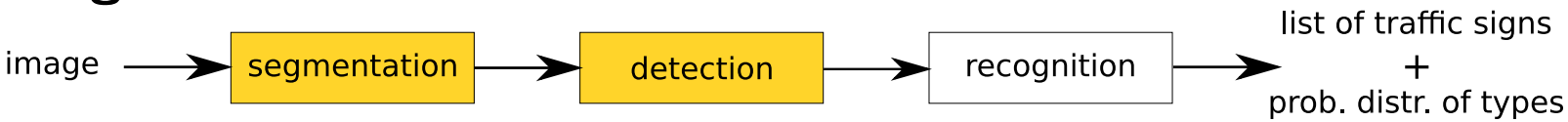

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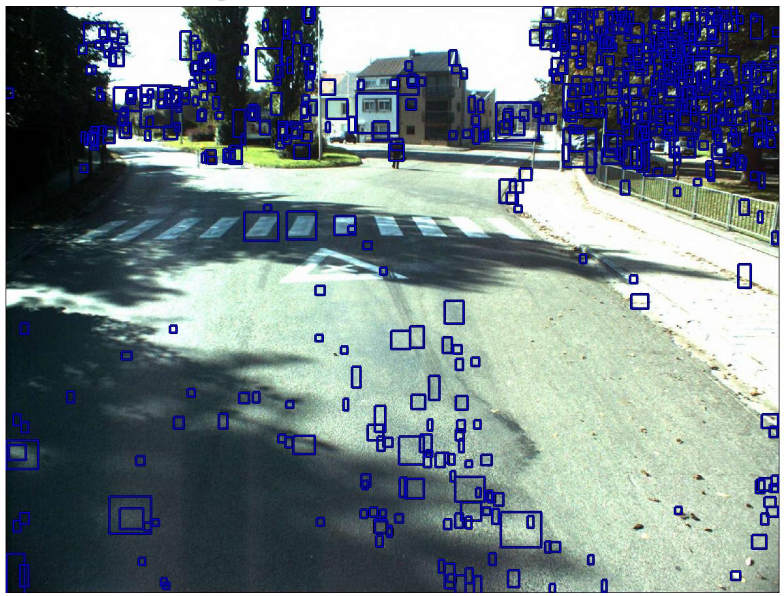

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Thresholding

- Segmentation is often detection of connected components of a thresholded image ($T = [0.5, 0.2, -0.4, 1.0]^\top$)

Original image	**Thresholded image $I(T)$**	**Connected components**	**Segmented bound. boxes**
			

- Threshold in RGB space: $T = [t, a, b, c]^\top$
- Thresholded image

$$I(T) = \begin{cases} 1 & a \cdot I_R + b \cdot I_G + c \cdot I_B \leq t \\ 0 & \text{otherwise} \end{cases}$$

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Learning segmentation

- One threshold insufficient $\Rightarrow$ set of thresholds $\mathcal{T} = \{T_1, T_2, \dots\}$ used.
- Different $\mathcal{T}$ different errors:
  - $FN(\mathcal{T})$ ..... False Negative (missed traffic signs)
  - $FP(\mathcal{T})$ ..... False Positive (segmented backgrounds)
  - $\mathrm{card}(\mathcal{T})$ ... Cardinality (size of $\mathcal{T}$)
- **Learning segmentation** is searching for $\mathcal{T} \subseteq \mathcal{P}\{\mathbb{T}\}$ minimizing an error subject to some constraints.
- Learning is NP-complete (set covering problem) but tractable even for very large $\mathcal{P}(\mathbb{T})$.

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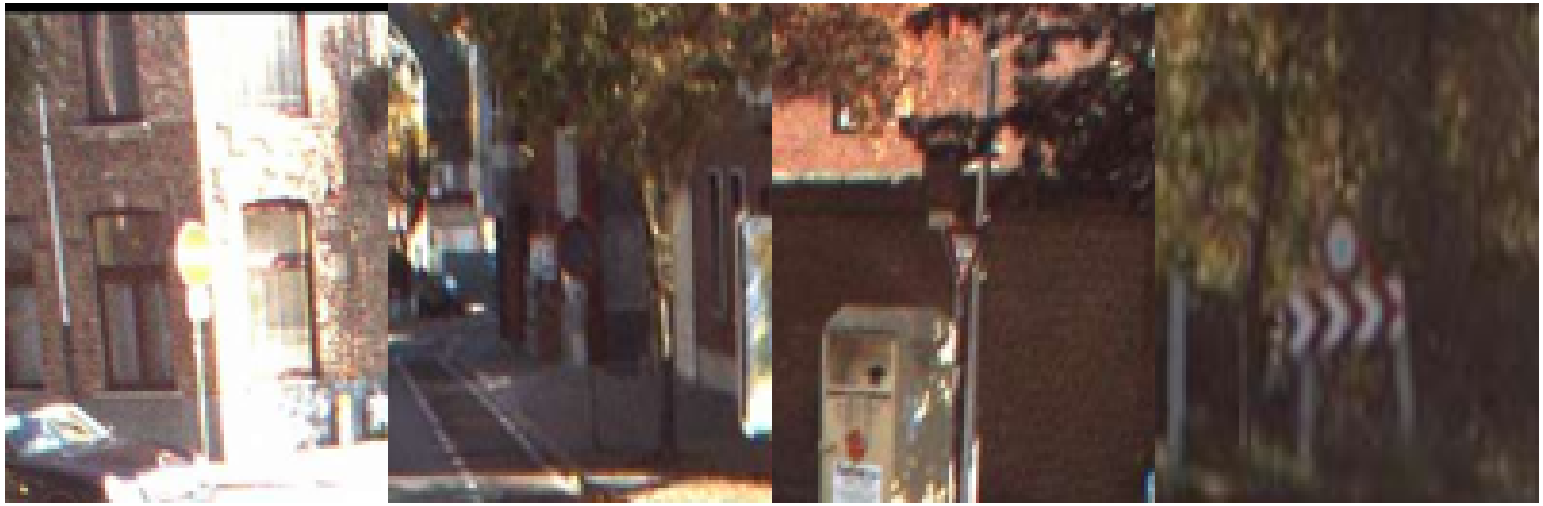
Experiments - Segmentation

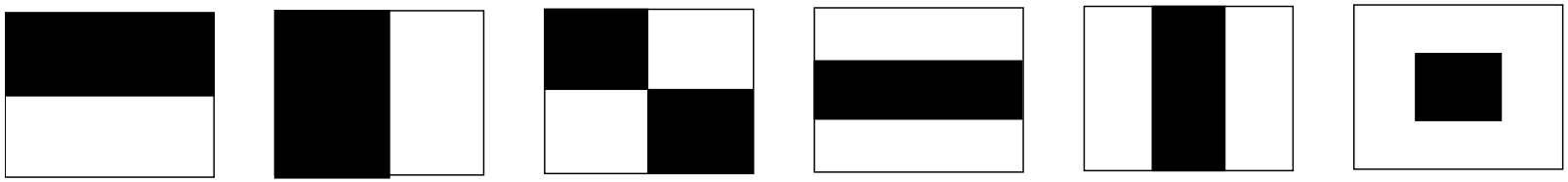
Neyman-Pearson

$(\epsilon = 5\%, \mathrm{card}(\mathbb{T}) = 10^4 \Rightarrow \mathrm{card}(\mathcal{P}(\mathbb{T})) = 2^{10^4})$

- Boolean linear programming optimization time less 2 sec.
- $\mathrm{card}(\mathcal{T}) \approx 30$ thresholds.
- $FP \approx 10^3$ bounding boxes per 1236×1628 image.
- $FN \approx 10$ missed traffic signs from 200 examples $\approx 5\%$.



Feature normalization



- Haar features
  - Feature normalization (RGB, HSL, HSV, gray)
  - Feature selection (greedy construction by AdaBoost)

Images from *www.wikipedia.org*

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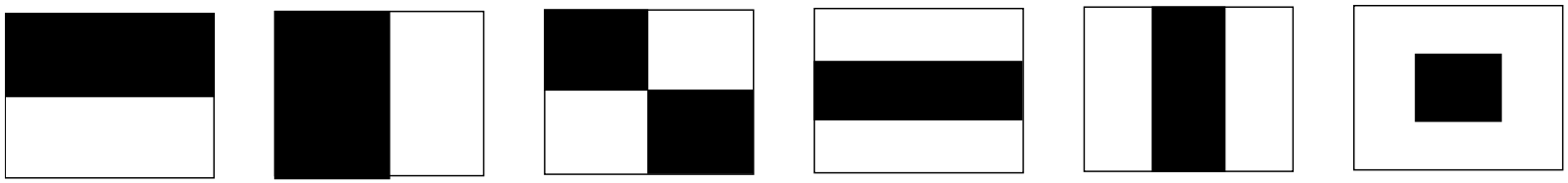

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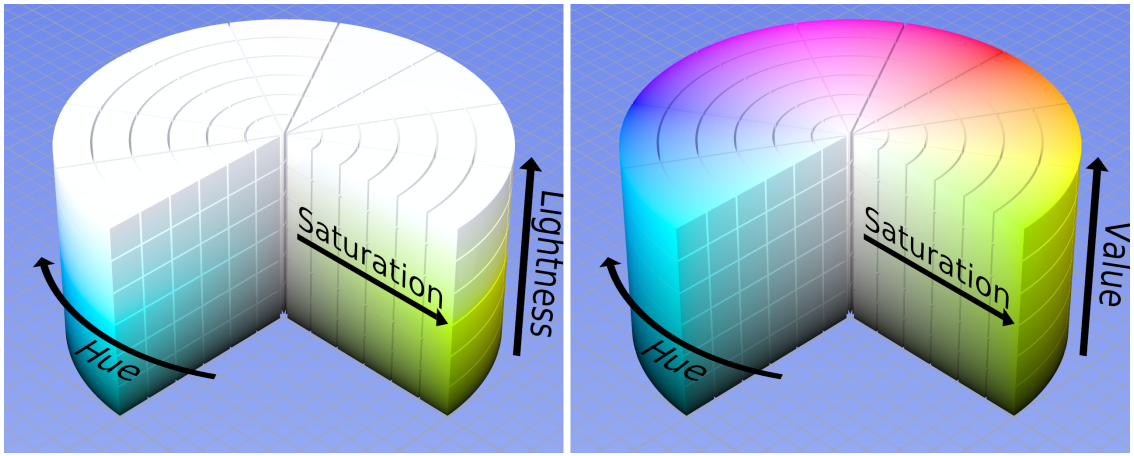

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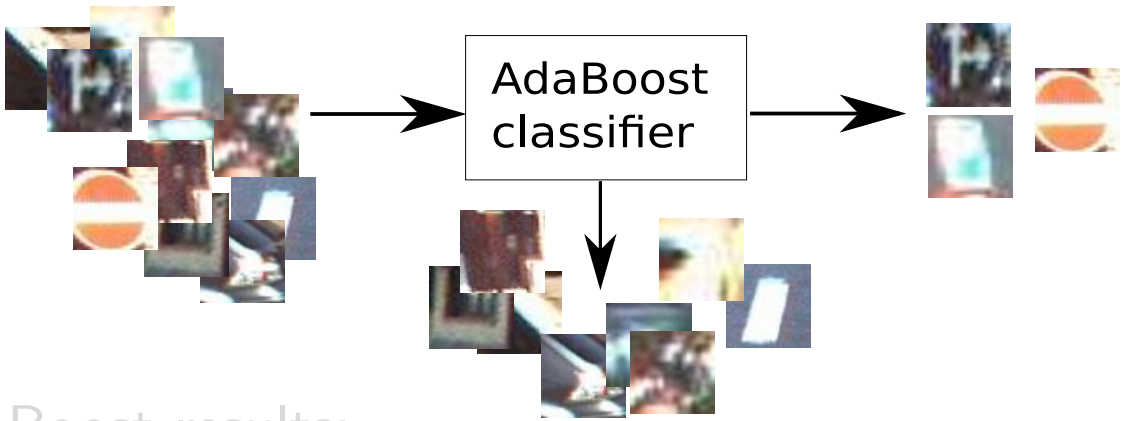
AdaBoost



- AdaBoost results:
  - 154 features selected from $5 \cdot 10^4$ features.
  - 77 minutes learning on 2400 training samples.

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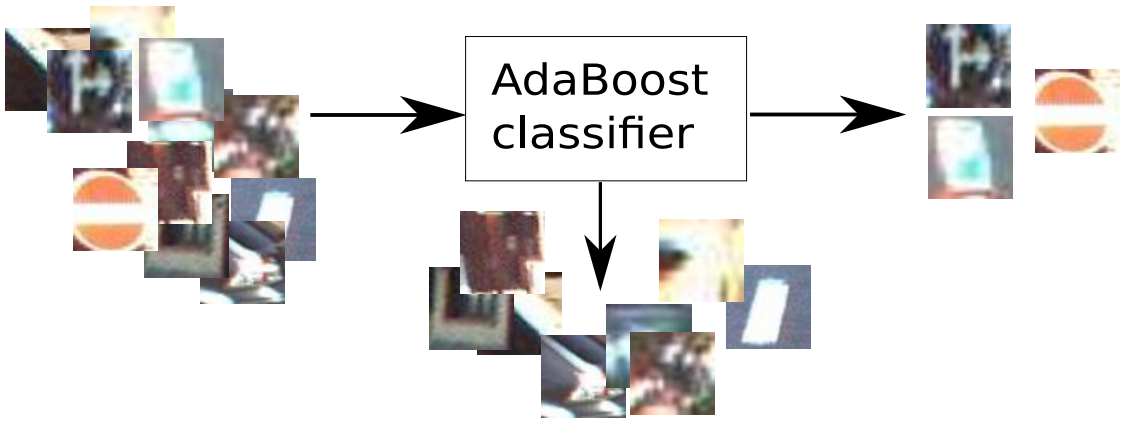

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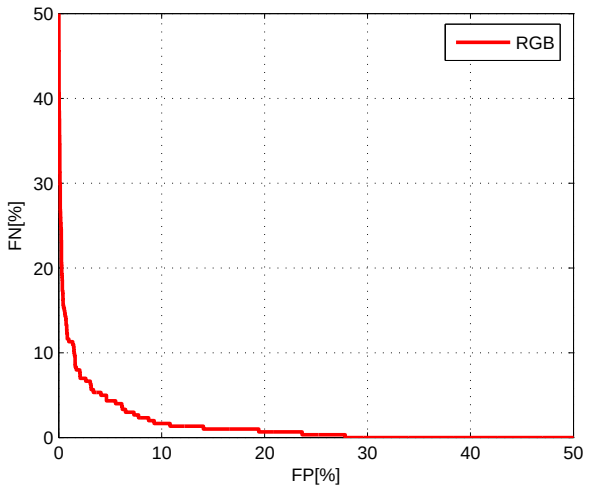
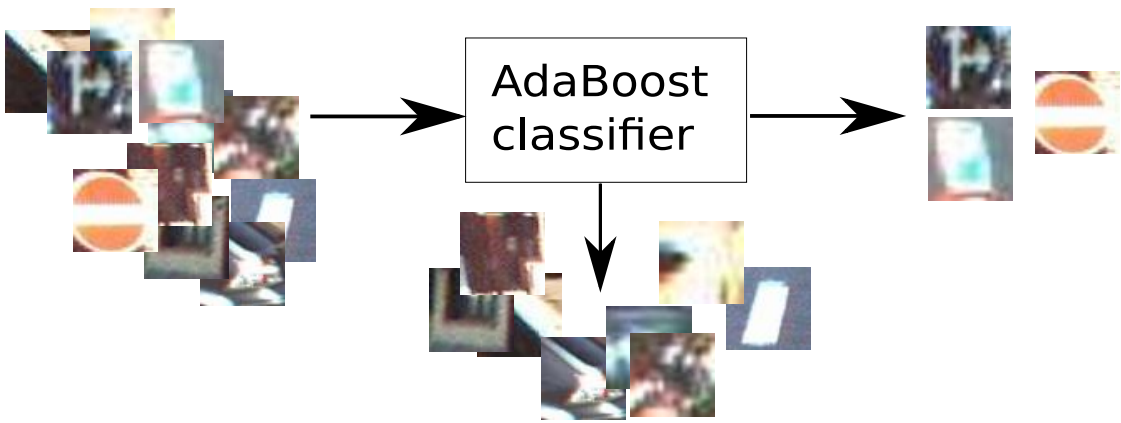


(AdaBoost) Cascade



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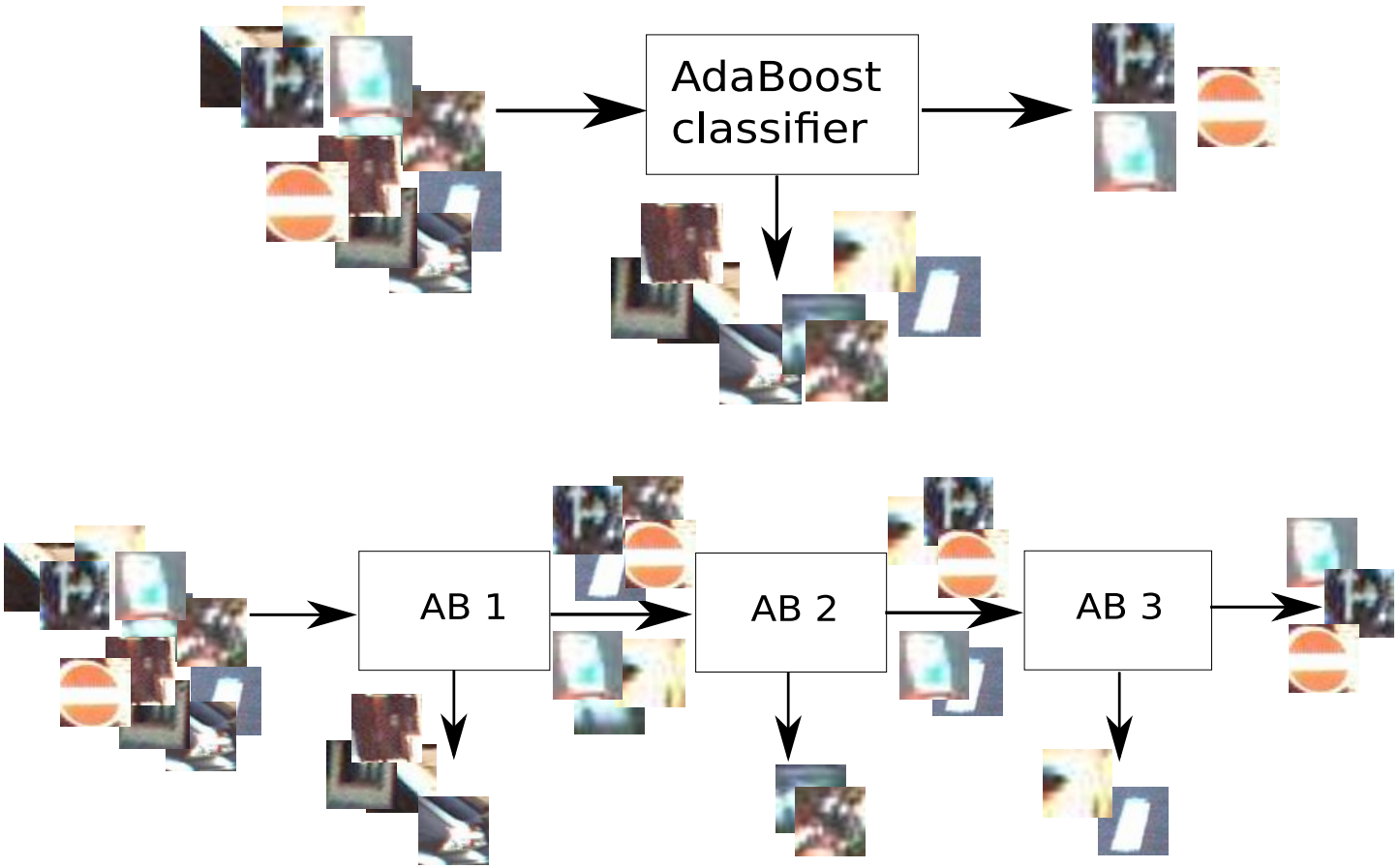

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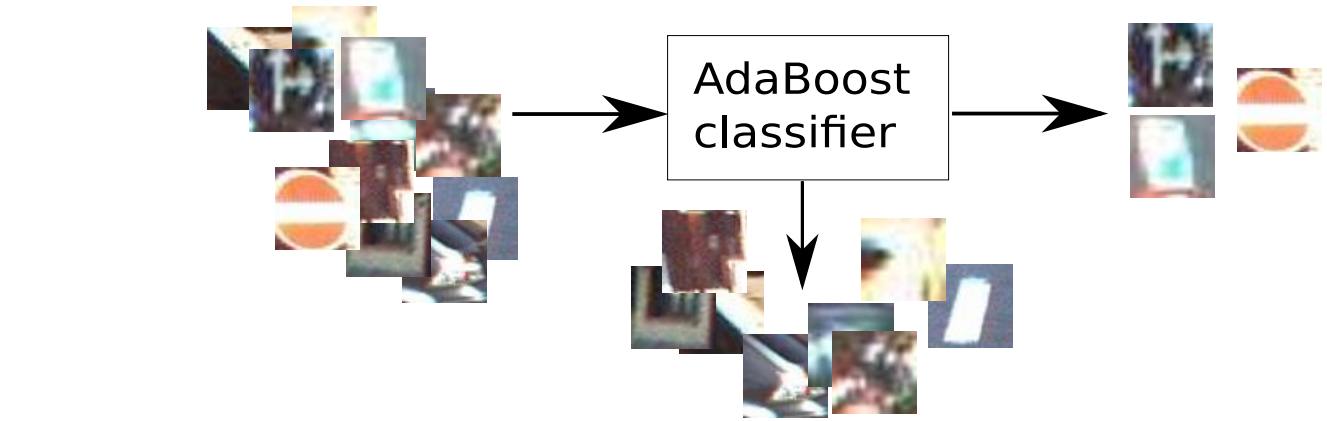
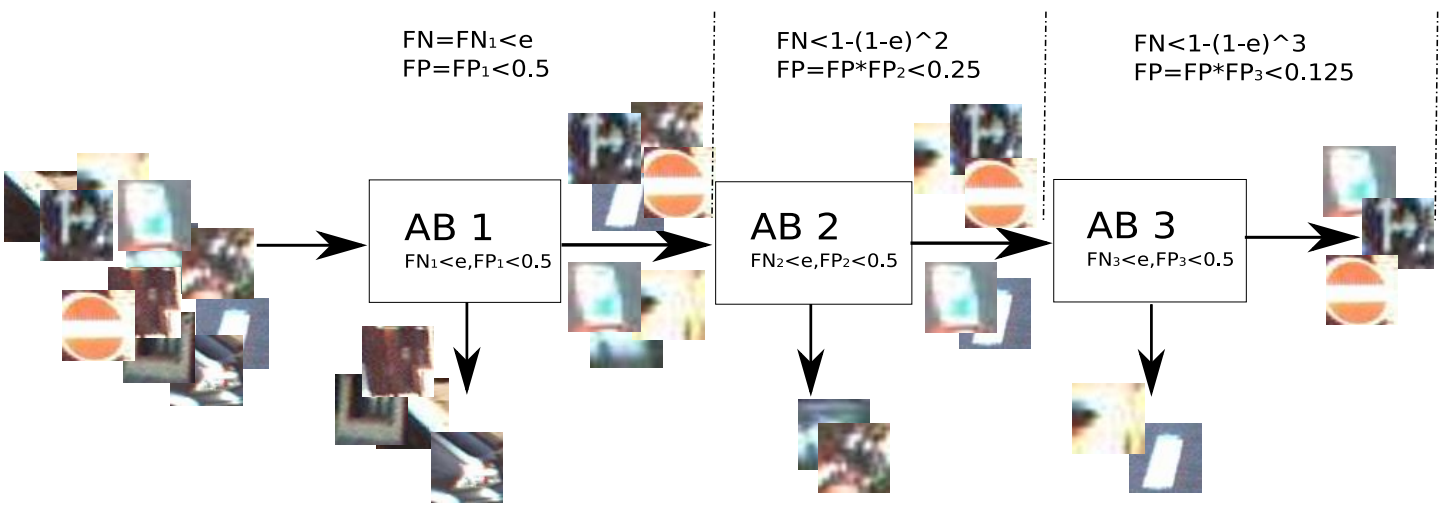
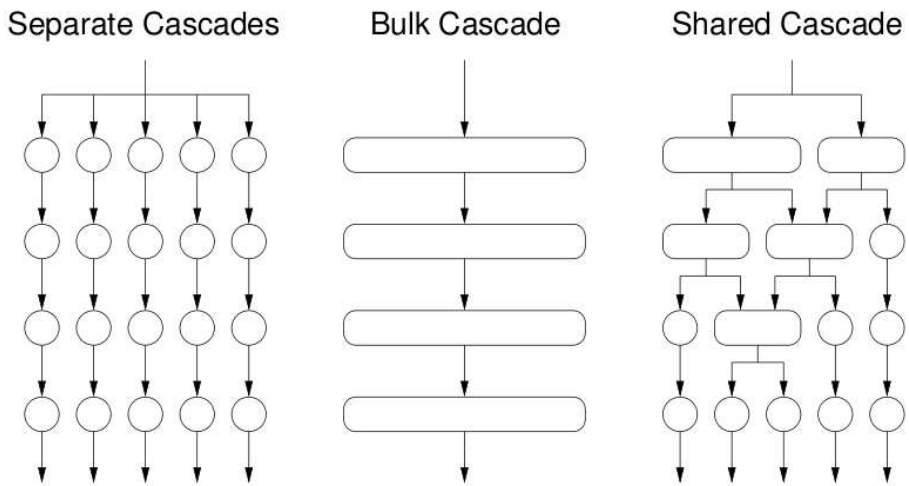




Multi-class detection by shared cascade [Zehnder et al. BMVC 2008]



Figures from *Zehnder et al.,BMVC2008*

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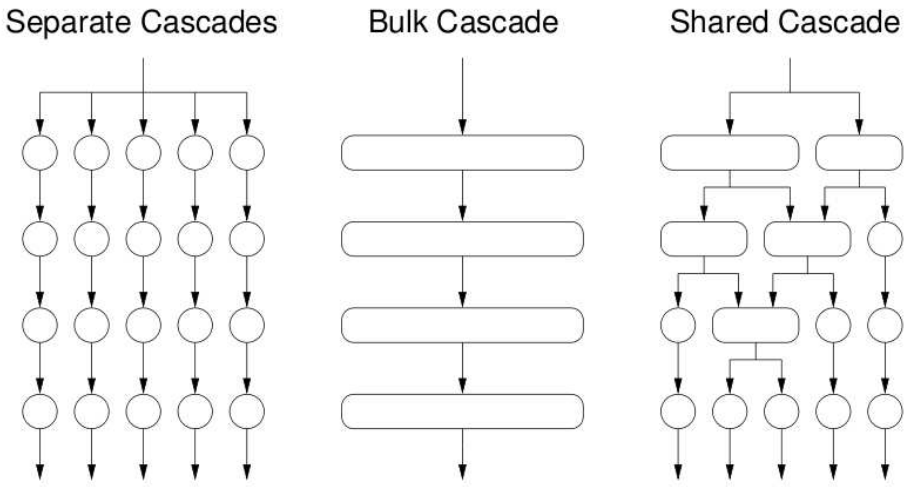

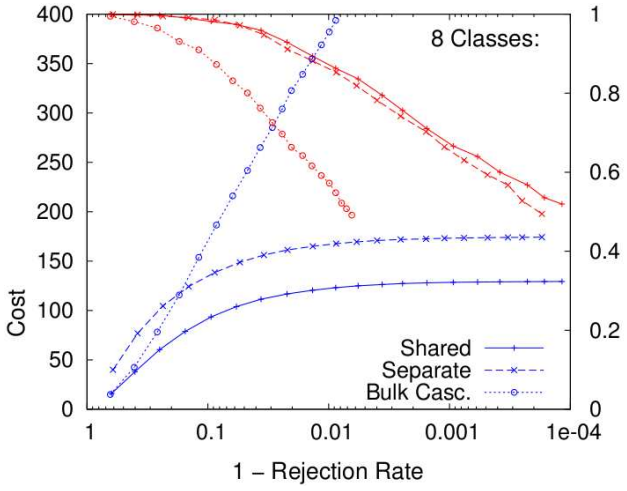

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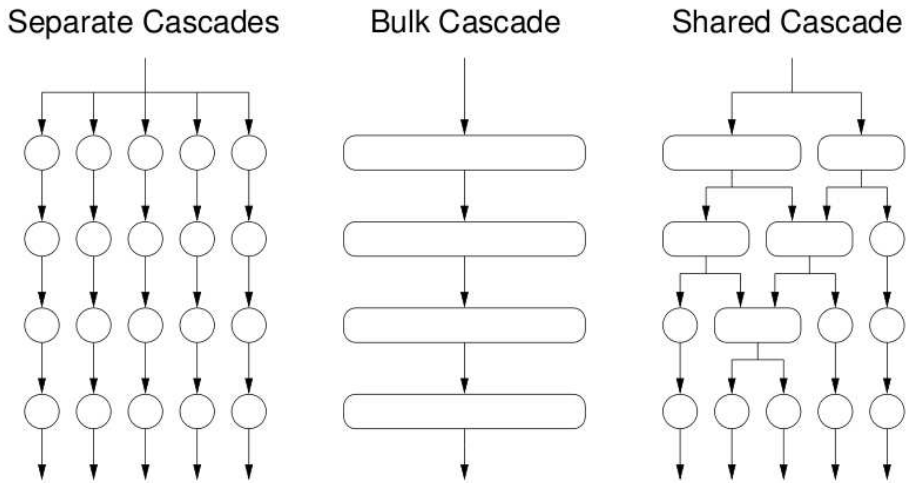

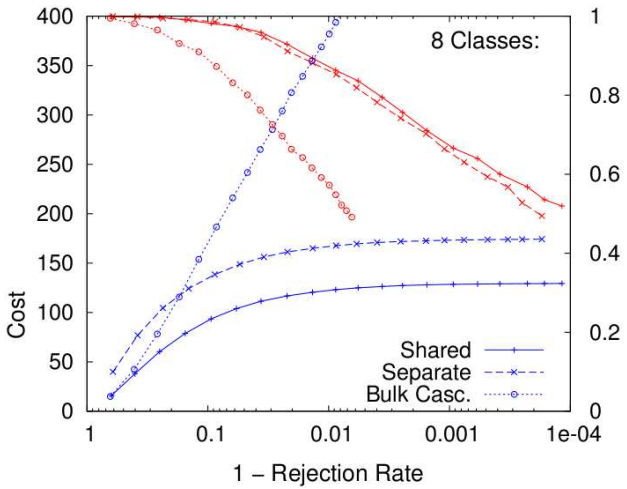

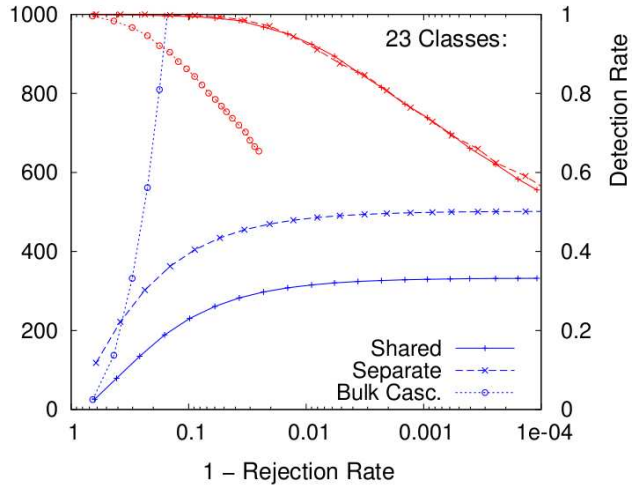

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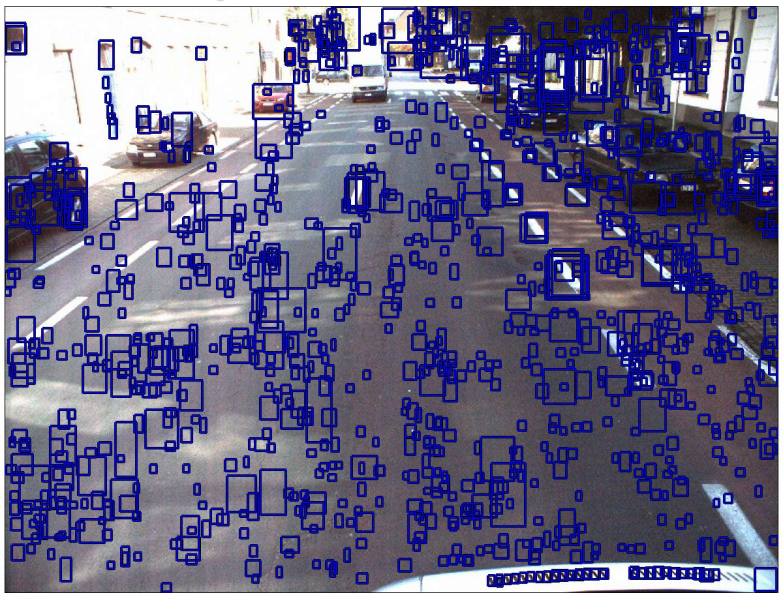

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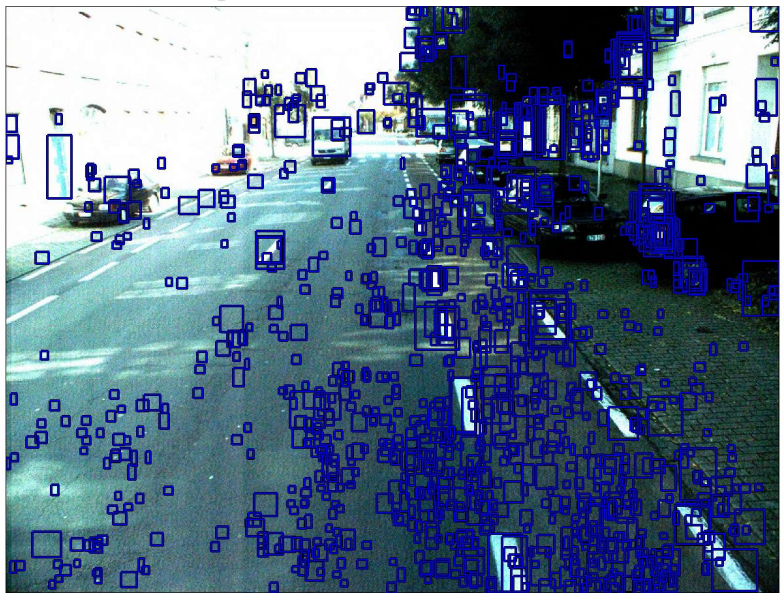

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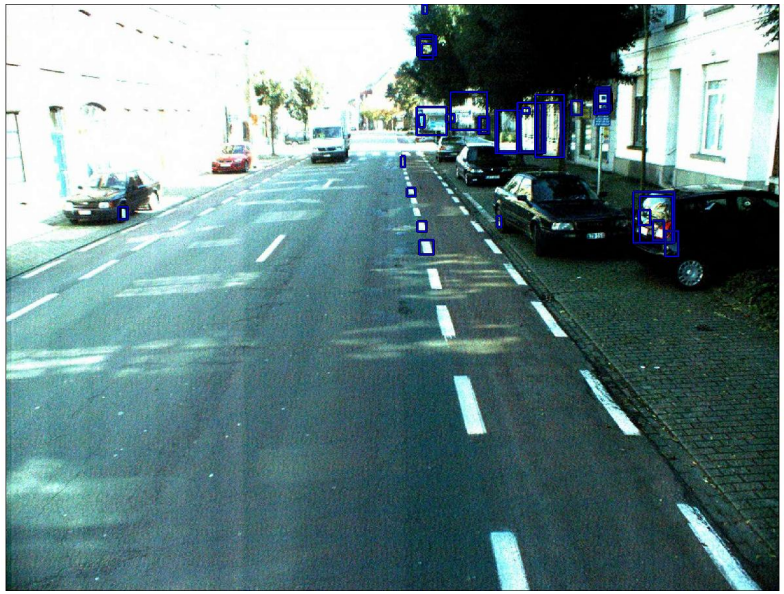

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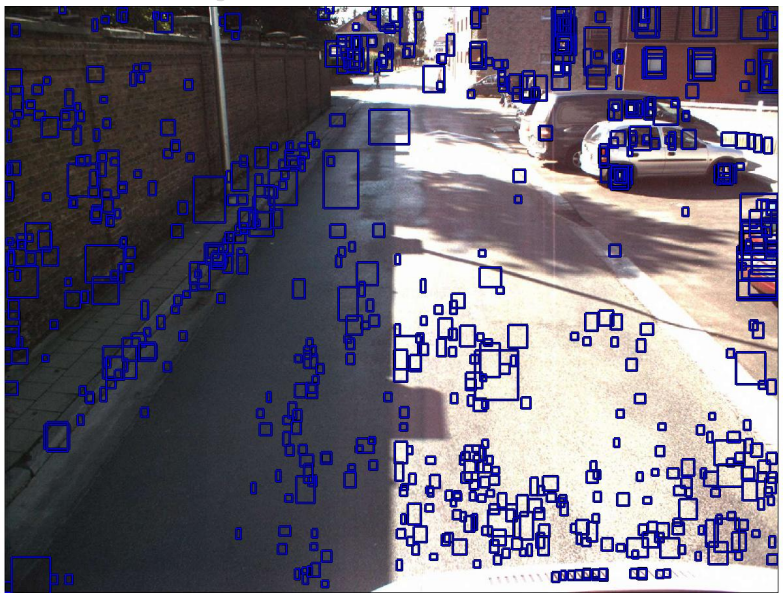

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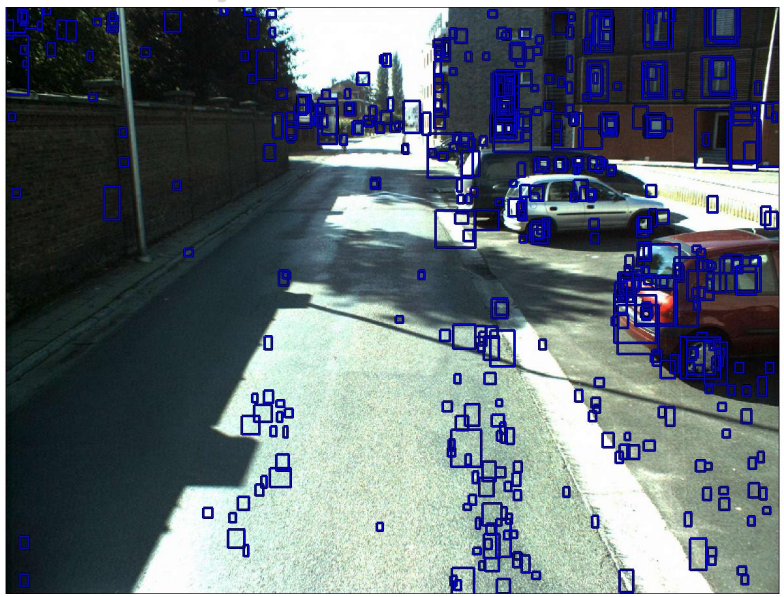

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