Nonlinear Background Filter to Improve Pedestrian Detection

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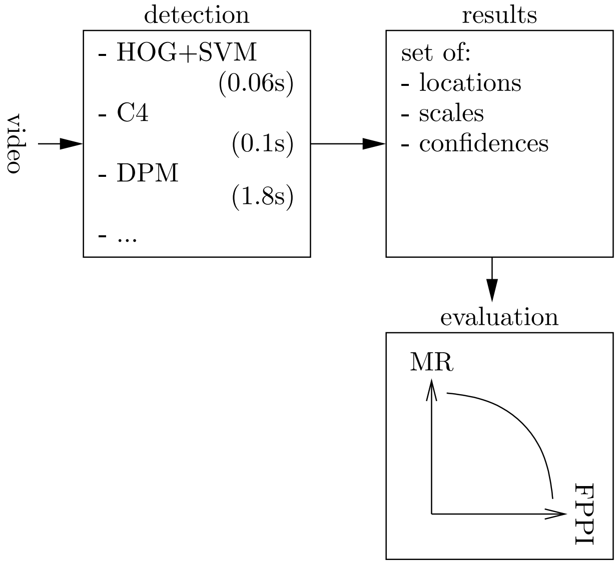
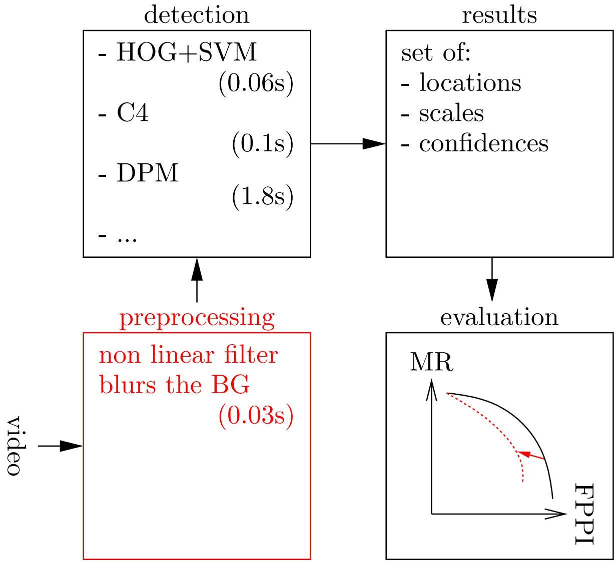
Object (*e.g.* pedestrian) detection



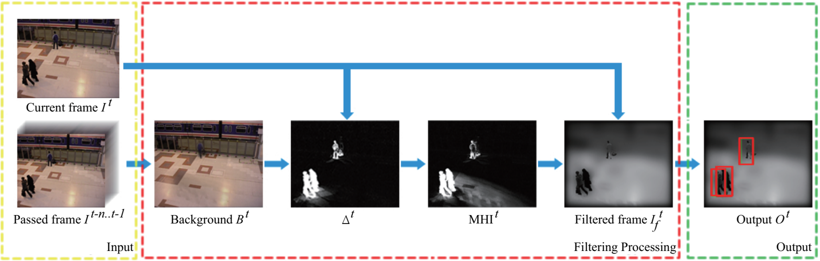
Object (*e.g.* pedestrian) detection



Outline

1. Proposed method
2. Results
3. Conclusion

Processing pipeline



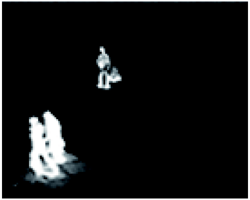
1. Estimation of the background image
2. Performing a very simple background subtraction (soft classifier)
3. Computing a motion history image (MHI)
4. Estimating $p(\text{foreground}|MHI)$
5. Choosing σ

Processing pipeline: detecting motion

- Input video sequence
  I^t
- Estimation of the background image
  $B^t = \beta\, I^t + (1-\beta)\; B^{t-1}$, with $\beta = 0.016$
- Very simple background subtraction (soft classifier)
  $\Delta^t = \text{Euclidean distance in RGB space}\;\; (I^t, B^t)$

I^t

B^t



Δ^t

Processing pipeline: predicting areas likely to contain potentially moving elements

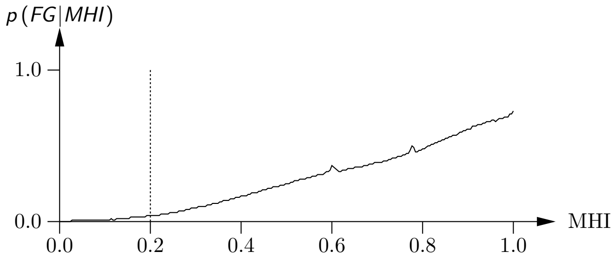
- Motion history image (*MHI*)

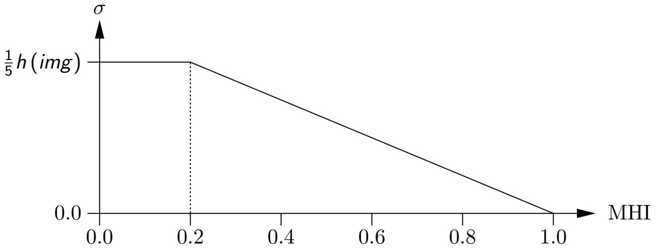
$$\begin{cases} \Delta^t & \text{if } \Delta^t \geq MHI^{t-1} \\ \alpha\,\Delta^t + (1-\alpha)\;MHI^{t-1} & \text{otherwise} \end{cases}, \text{ with } \alpha = 0.8$$

input image → motion history image

Processing pipeline: choosing the magnitude of filtering

- $p\left(\text{foreground}|MHI\right) = ?$
- $p\left(\text{foreground}|MHI\right)\downarrow \Rightarrow \sigma^t_{x,y}\uparrow$
  $p\left(\text{foreground}|MHI\right)\uparrow \Rightarrow \sigma^t_{x,y}\downarrow$

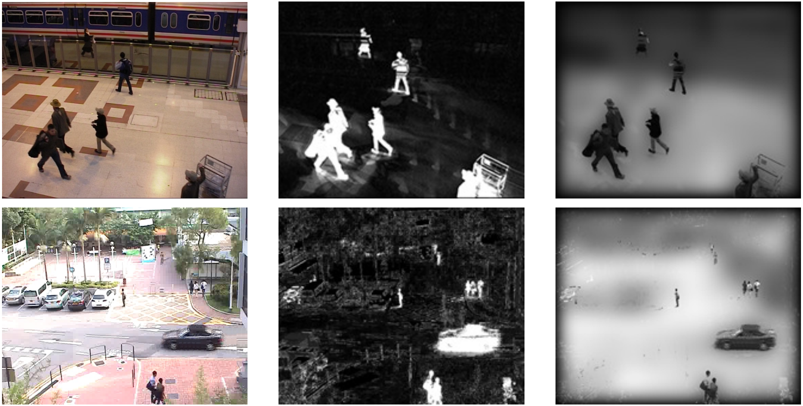




Processing pipeline: result of the preprocessing

$$I_f^t = I^t \otimes \mathcal{G}\left(0,\, \sigma_{x,y}^t\right)$$

input image I^t $\rightarrow$ motion history image $\rightarrow$ filtered image I_f^t



Processing pipeline: result of the preprocessing

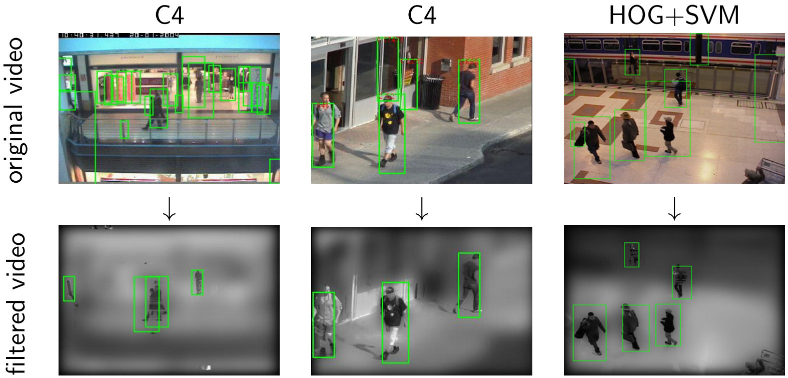
(click here to play video)

Processing pipeline: result of the preprocessing

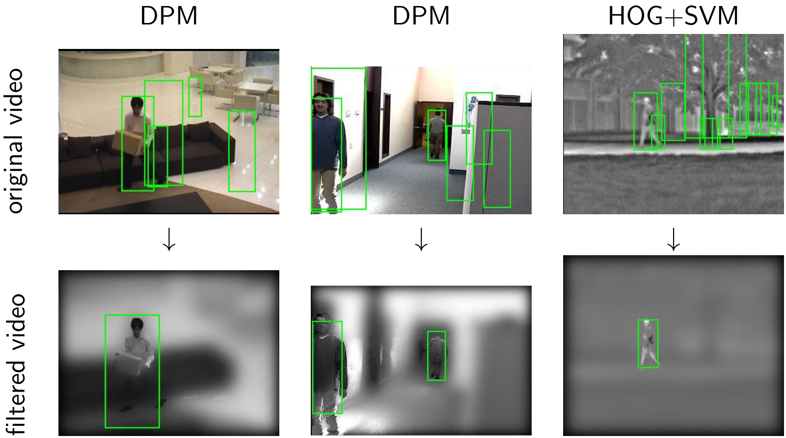
(click here to play video)

Outline

Improvement for three pedestrian detectors



Improvement for three pedestrian detectors

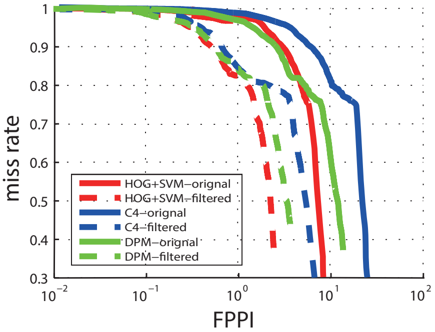


Improvement for three pedestrian detectors

Improvement shown on a video

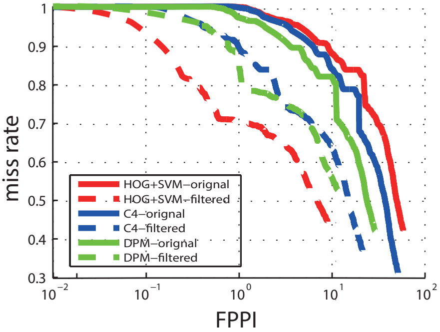
(click here to play video)

Improvement for the category “baseline”



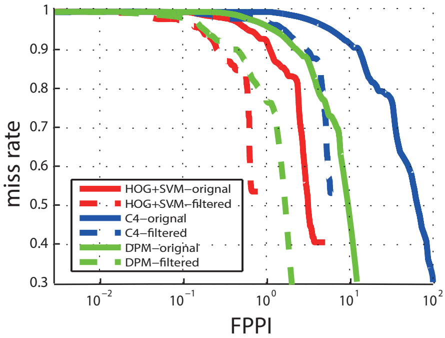
Legend:
solid lines: 3 detectors applied on the original videos
dashed lines: the same detectors applied on the preprocessed videos

Improvement for the category "small pedestrians"



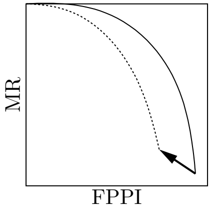
Legend:
solid lines: 3 detectors applied on the original videos
dashed lines: the same detectors applied on the preprocessed videos

Improvement for the category “top-down”



Legend:
solid lines: 3 detectors applied on the original videos
dashed lines: the same detectors applied on the preprocessed videos

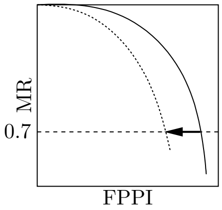
Analysis of the results: tradeoff between FPPI and MR



		Baseline		Small pedestrians		Top-down	
		MR ↗	FPPI ↘	MR ↗	FPPI ↘	MR ↗	FPPI ↘
detector	HOG+SVM	1.4	3.5	1.1	6.5	1.3	6.4
	C4	1.1	3.6	1.2	2.4	1.9	16.5
	DPM	1.2	3.8	1.3	2.5	1.5	6.8

The FPPI decreases on average by a factor of 5.8 for each detector while the miss rate increases on average by a factor of only 1.3.

Analysis of the results: systematic improvement of FPPI



Detector		Baseline	Small pedestrians	Top-down
HOG+SVM	Original	5.9	**10.4**	2.6
	Filtered	1.6	**0.4** (÷26)	0.6
C4	Original	18.5	6.6	35.3
	Filtered	3.8	2.0	5.2
DPM	Original	8.3	**4.0**	7.1
	Filtered	2.3	**1.9** (÷2.1)	1.3

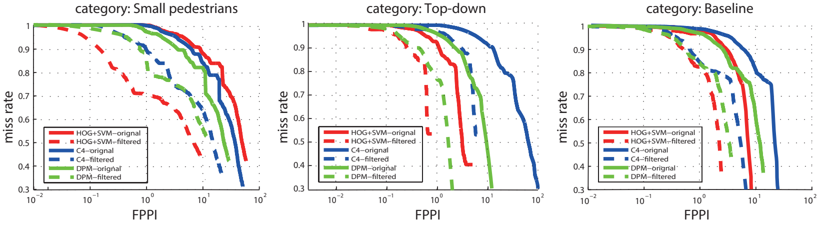
Our method systematically decreases the the FPPI (2.1 to 26×).

Outline

Conclusion

Estimating the background allows one to compute a MHI, which is effective for predicting areas unlikely to contain potentially moving objects such as pedestrians.

Adaptive filtering to blur these areas is a preprocessing that significantly improves the detection ability of almost any exiting moving object detector (unmodified $\Rightarrow$ black box).



We continued to work on this topic and have now other, better, results. A journal paper will follow with the explanation . . . stay tuned!