Simple Median-Based Method for Stationary Background Generation Using Background Subtraction Algorithms

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Introduction

- We want to estimate an image containing the background (BG) of a scene taken from a static viewpoint.

- This problem can be solved by applying a temporal median filter per pixel **if the foreground (FG) is visible less than half of the time** (*MED method*).

- For most of the sequences of the SBI dataset, it is not the case!

Ideas

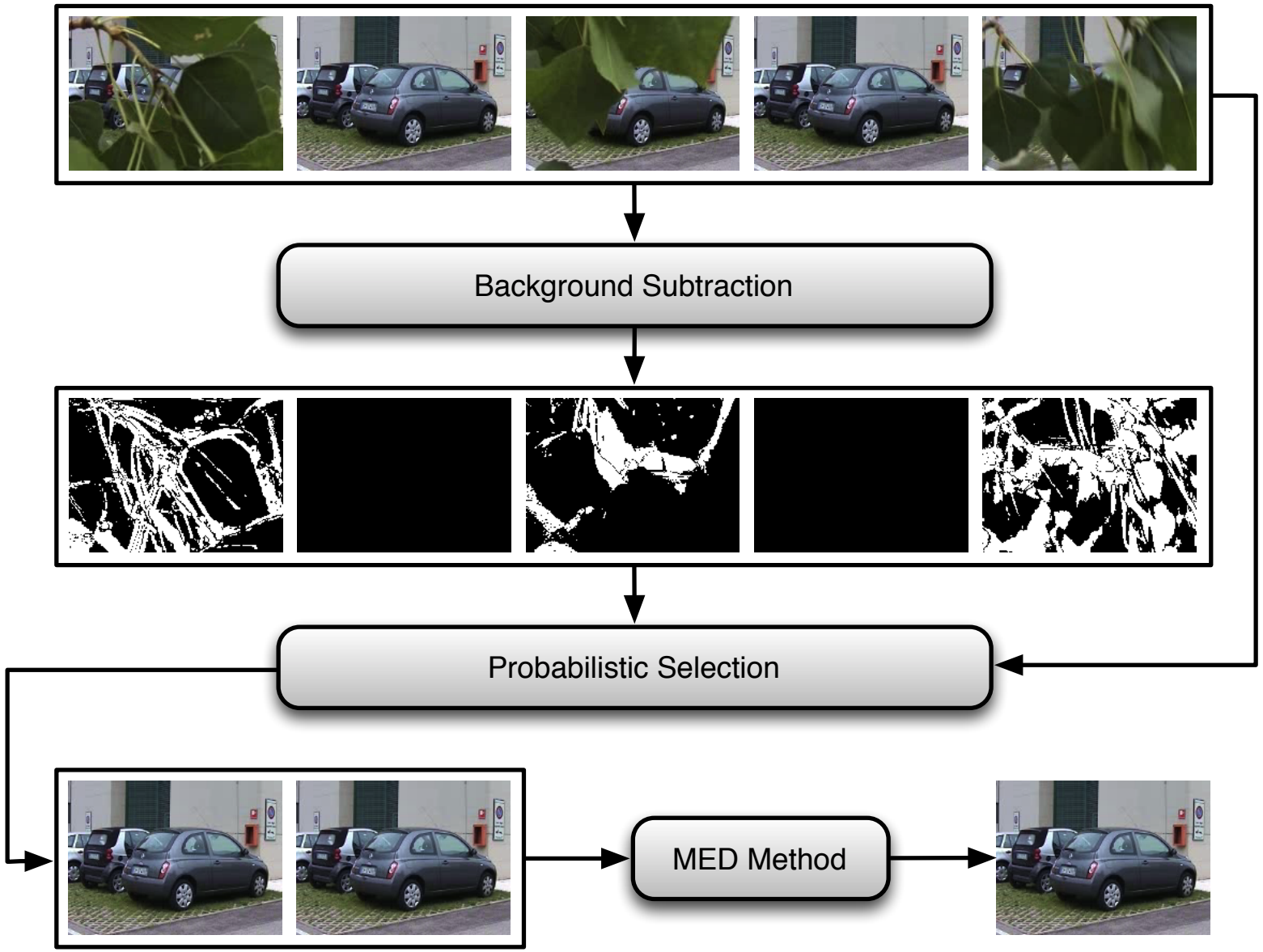
In order to get the MED method work:

1. Select a set of relevant frames to have the BG visible for half of the time.
2. Such a selection could be based on motion, discarding the frames containing a large “amount of motion”.

Observation

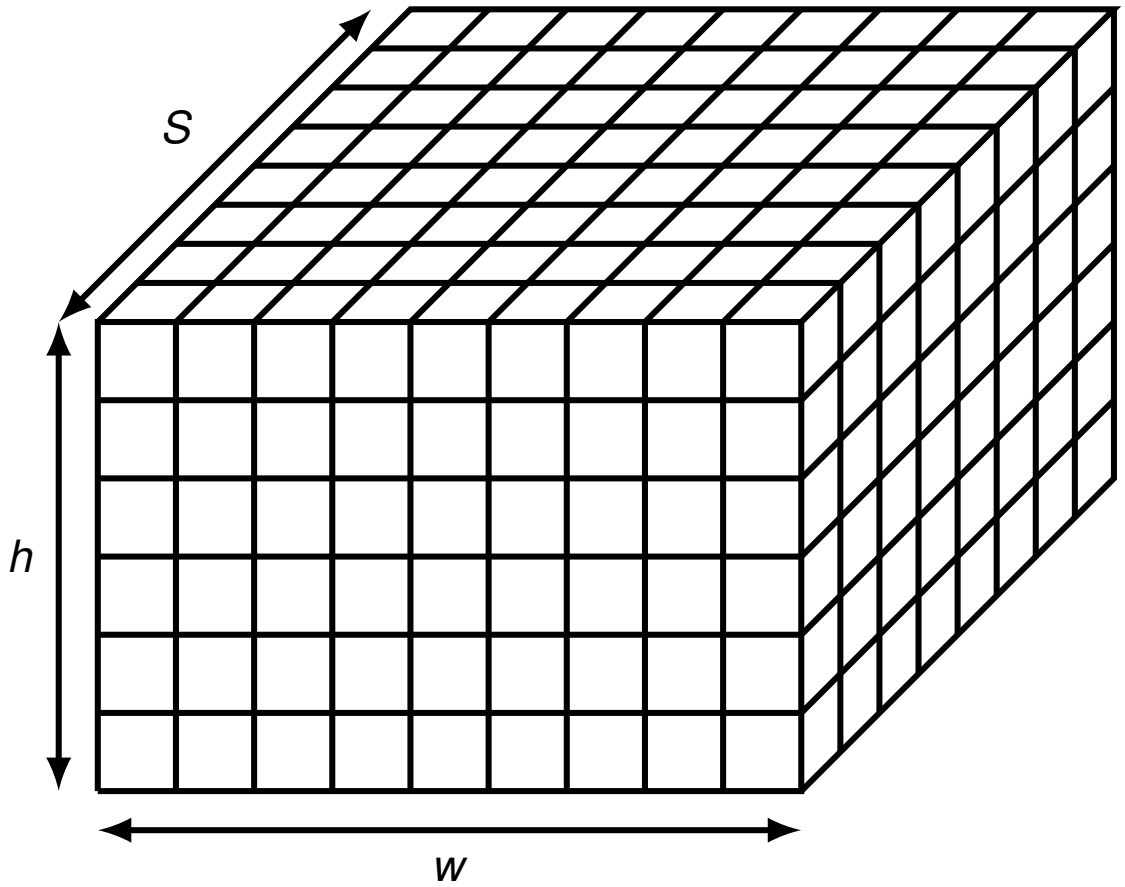
Background subtraction (BGS) algorithms can detect motion!

Ideas: Graphical Summary



Proposed Method: Buffers

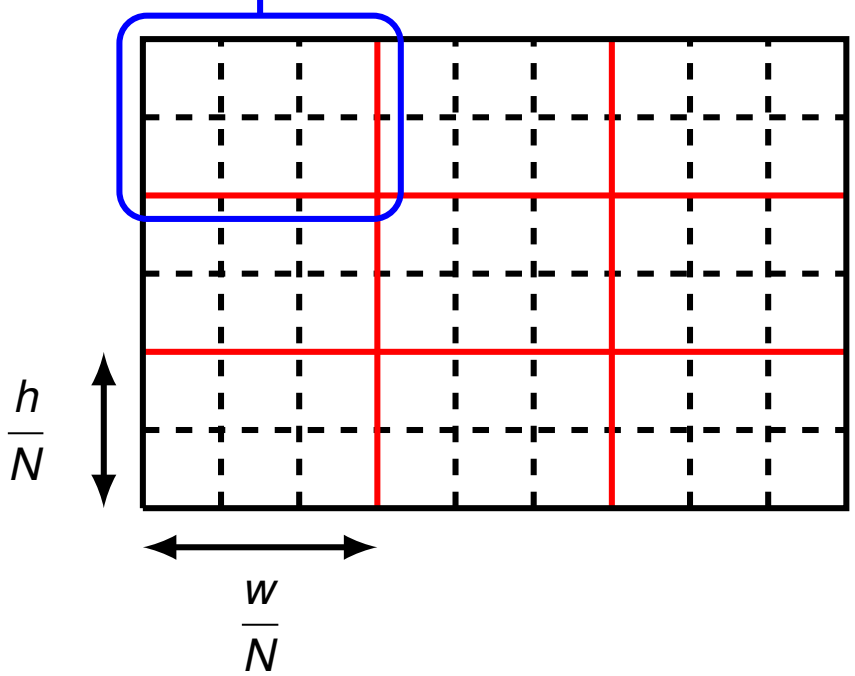
- Median computed on a per-pixel subset of *selected* values.
- The size of the subsets is fixed by the S parameter.



Proposed Method: Patches

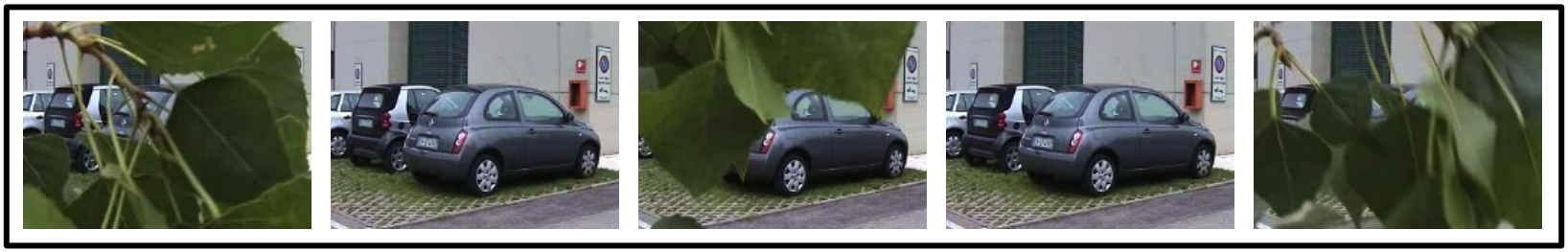
- The image plane is divided in $N \times N$ (parameter) non-overlapping patches.
- An observed value is selected according to a probability denoted p^*_+ of FG elements in the patch of the considered pixel.
- Pixels are classified as FG or BG using a BGS algorithm (denoted by A).

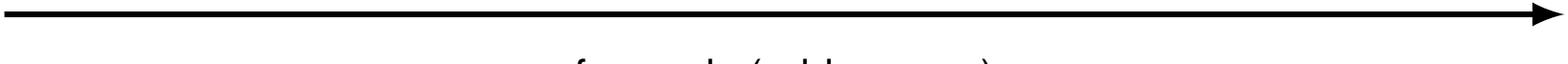
$$p^*_+ = \frac{\#\text{ pixels classified as foreground in the patch}}{\#\text{ pixels in the patch}}$$



Proposed Method: Passes

- BGS algorithms need an initialization period.
- The number of frames needed for this period is algorithm dependent.
- It can be larger than the number of frames in the sequences of the SBI dataset.
- We process the sequences with several passes.
- The number of passes (γ parameter) is chosen to be odd.





forwards (odd passes)

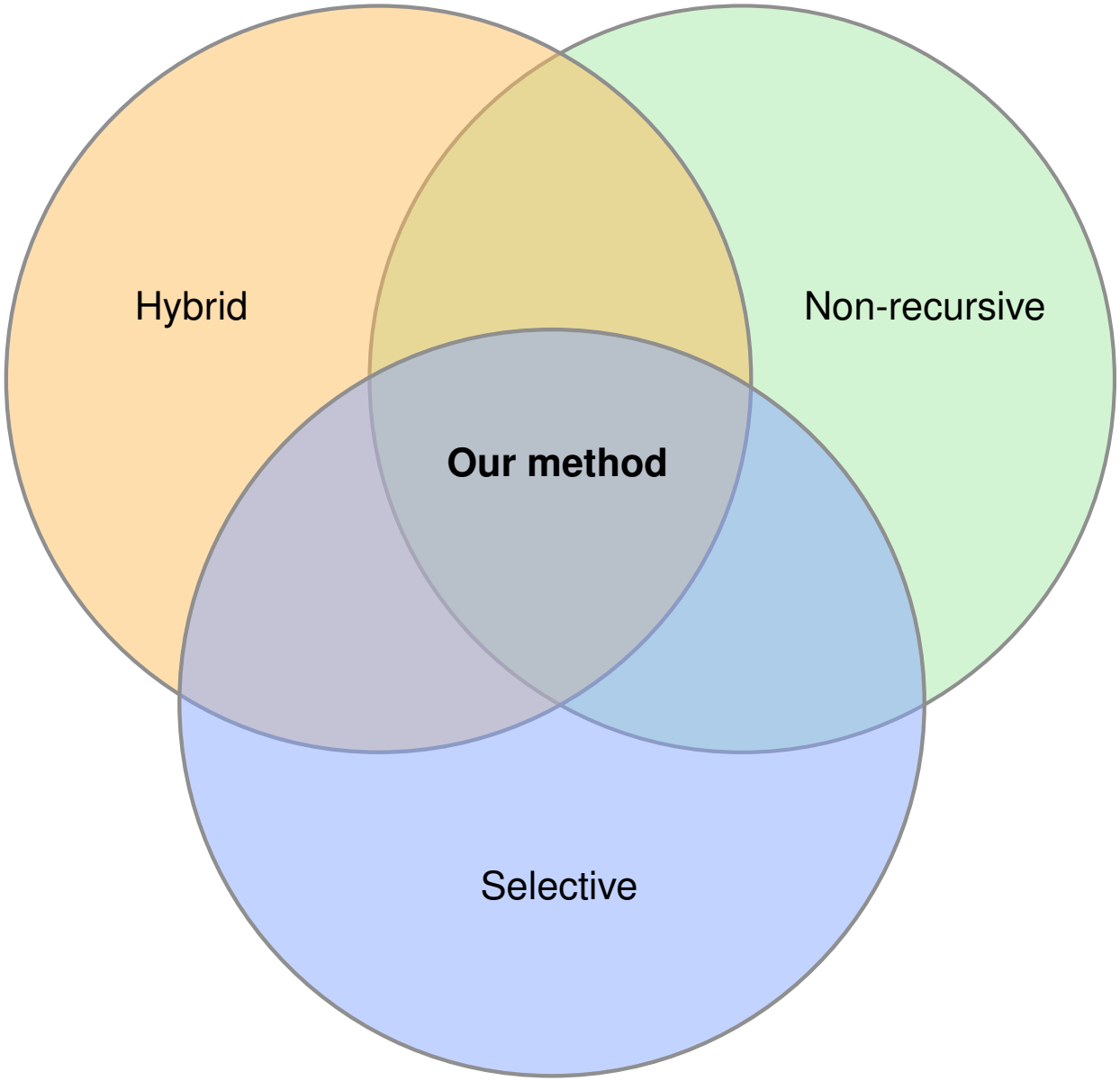
backwards (even passes)

Proposed Method: Processing

For each pixel:

- Our method selects the S values, encountered during the γ passes, with the lowest probability p^*_+.
- When S is too small to select all the values with equal p^*_+ probabilities, the last encountered ones are selected.
- At the end of the γ passes, the BG color is estimated by the median of the S selected values.

Classification (According to Maddalena and Petrosino)



Experiments

The proposed method has been tested with all combinations of:

- $A \in \{$ F. Diff, Pfinder, MoG G., MoG Z., S-D, KDE, ViBe, PBAS, SuBS., SOBS $\}$
- $S \in \{5, 11, 21, 51, 101, 201\}$
- $N \in \{1, 3, 5, 10, 25, 50\}$
- $\gamma \in \{1, 3, 5, ..., 19\}$

Note that, for our results, we arbitrarily chose to work with the pEPs metric.

Results

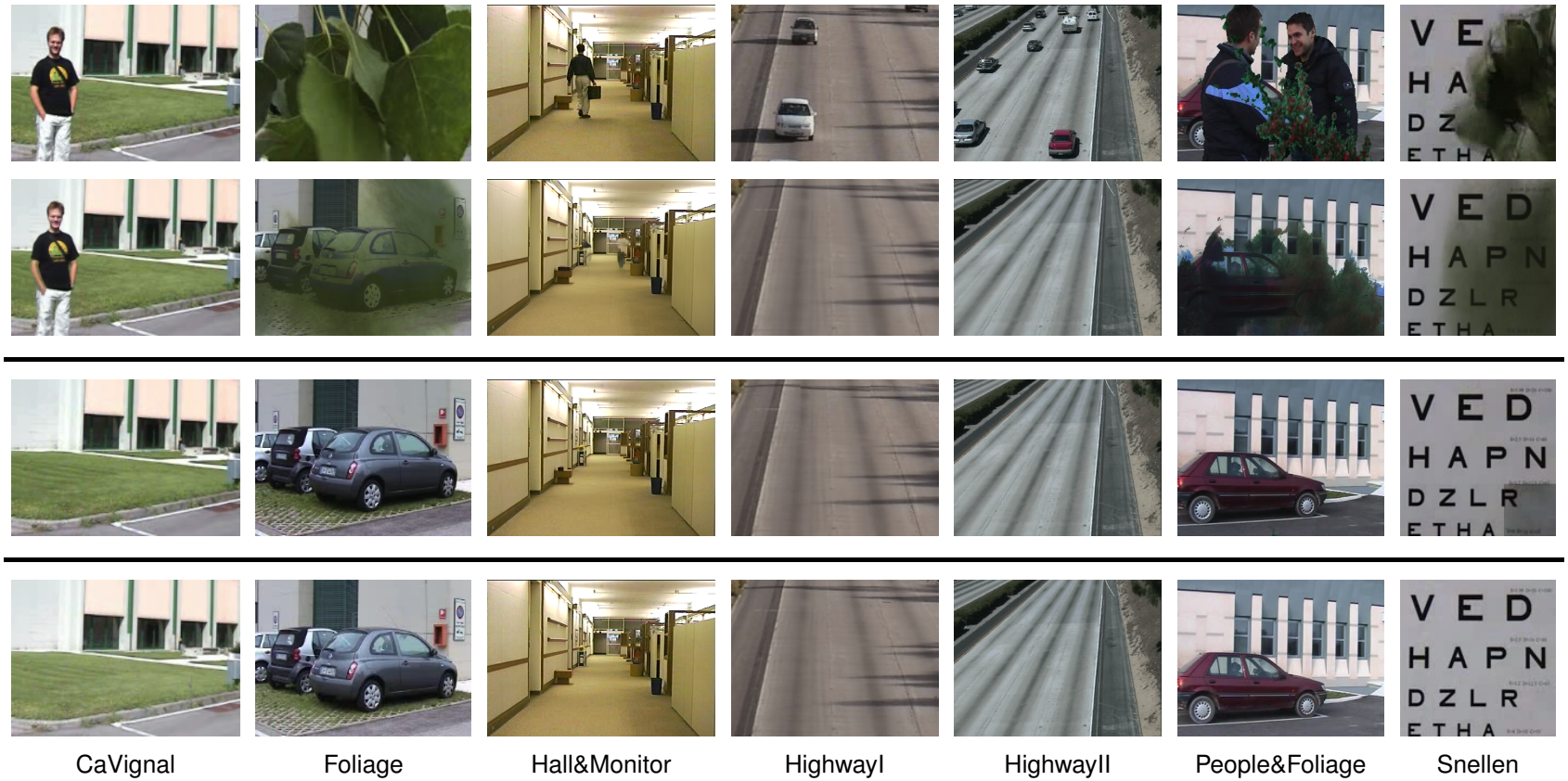


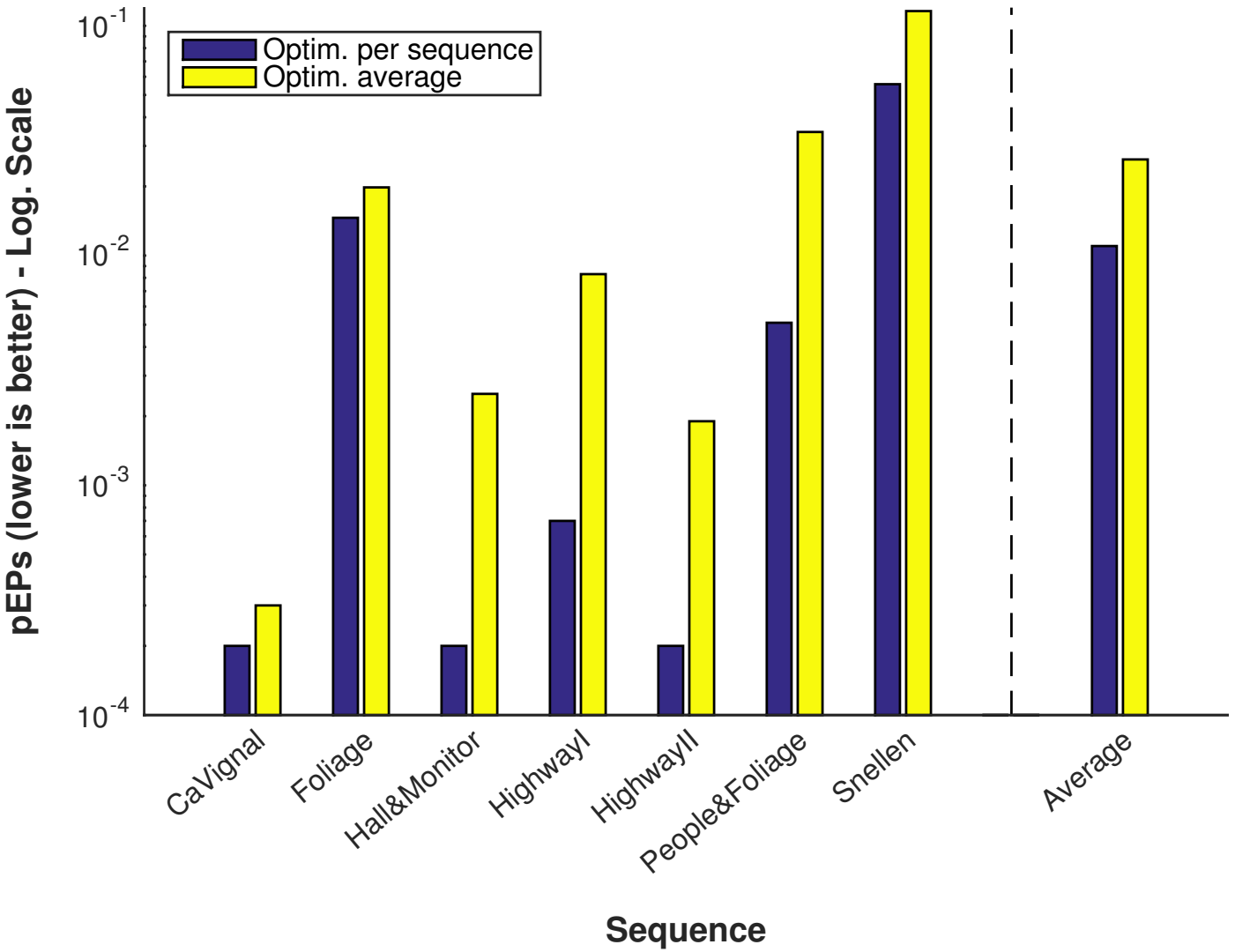
Figure : The 7 video sequences of the SBI dataset (50th frame on the 1st row), the result obtained by the MED method (2nd row), the result obtained by minimizing the pEPs score averaged over all the sequences ($A =$ F. Diff., $S = 21$, $N = 3$, $\gamma = 11$) (3rd row), and the corresponding ground-truth (4th row).

Results: Metrics POV

Sequence	AGE	**pEPs**	pCEPs	MS-SSIM	PSNR	CQM
CaVignal	9.2286	**0.0003**	0.0000	0.9933	27.5385	39.7264
Foliage	11.9949	**0.0198**	0.0000	0.9916	26.0057	34.0230
HallAndMonitor	2.5051	**0.0025**	0.0004	0.9880	35.0603	43.1707
HighwayI	2.1235	**0.0083**	0.0018	0.9833	35.8519	52.9773
HighwayII	2.2706	**0.0019**	0.0000	0.9927	37.2908	45.7950
PeopleAndFoliage	12.2607	**0.0345**	0.0014	0.9902	25.6114	33.5995
Snellen	17.0920	**0.1159**	0.1000	0.9646	21.2595	41.0757
Average	8.2108	**0.0262**	0.0148	0.9863	29.8026	41.4811

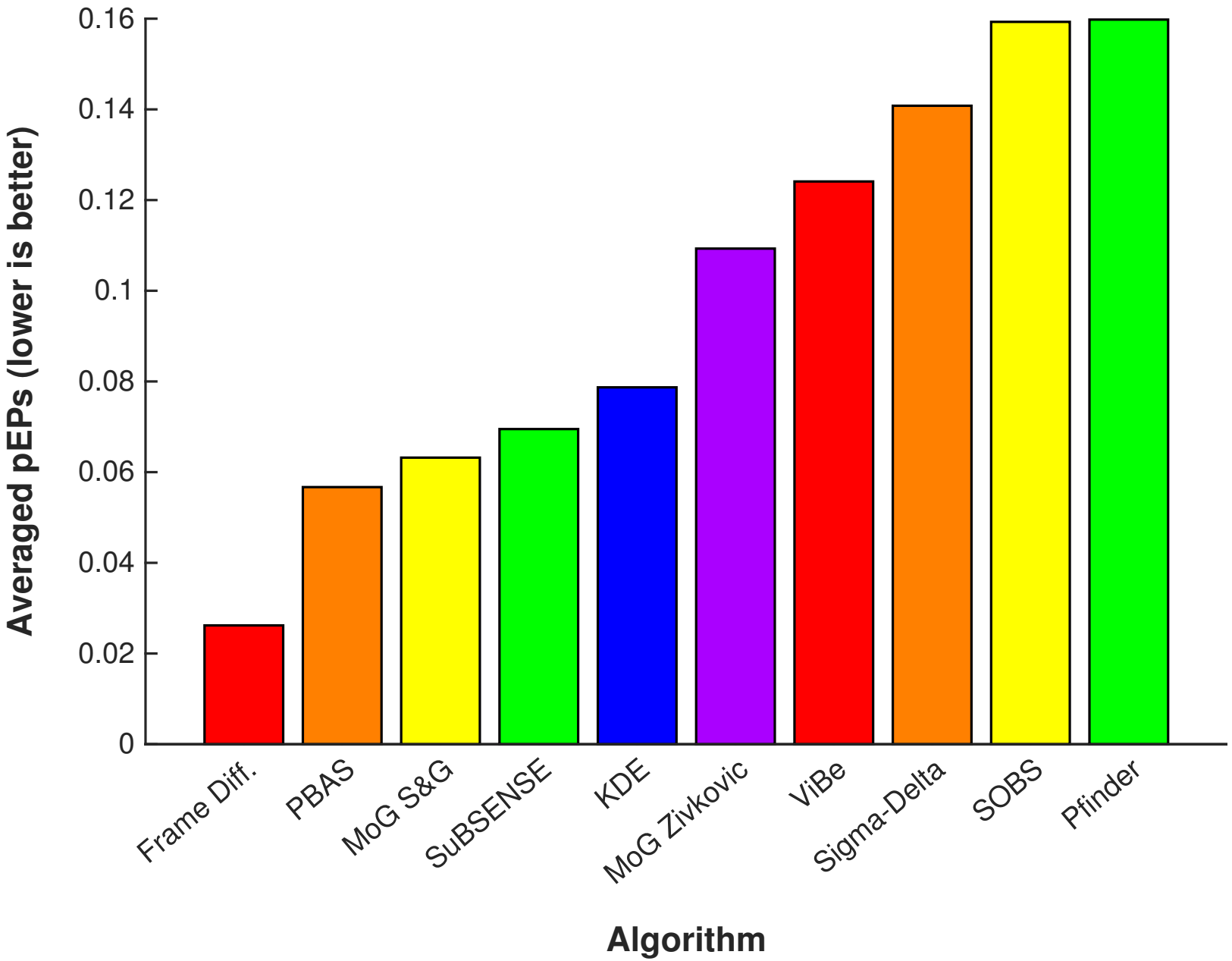
Table : Scores computed on the results obtained by minimizing the pEPs score averaged over all the sequences ($A =$ F. Diff., $S = 21$, $N = 3$, $\gamma = 11$).

Optimal Set of Parameters Per Sequence



- Improvement from 0.0001 (CaVignal) to $\simeq$ 0.06 (Snellen).
- Mean improvement $\simeq$ 0.015.
- Note that the optimal BGS algorithm is not the same for all the sequences.

Optimal Set of Parameters Per BGS Algorithm



Conclusion

- New method to estimate the background image of a cluttered static scene.
- The method is simple and easy to implement.
- It allows to embed any BGS algorithm without any modification as we only use the segmentation maps.
- Surprisingly, the frame difference outperforms more advanced BGS algorithms in this particular context.
- The obtained results are almost free of foreground objects.
- Source code is available: `http://hdl.handle.net/2268/182893`.

Thank you for your attention!

Do you have questions?