Fast Recursive Ensemble Convolution of Haar-like Features

Daniel Wesierski (Telecom SudParis)
Maher Mkhinini (Telecom SudParis)
Patrick Horain (Telecom SudParis)
Anna Jezierska (Université Paris-Est)

Objective

Speed-up the convolution of Haar-like features (HLFs) for computer vision applications

Approach

Classical convolution: read the values at corners

☹ **Redundant I/Os**

Bottleneck: data transfer

☞ **Reduce I/O !**

Evaluation

Example configurations:

- Speeded-Up-Robust-Features (SURF)
- Initial HLF for OpenCV face detection (FACE)

Theoretical acceleration:

$$\frac{I_{class}+1}{I_{prop}+O_{prop}+1}$$ where

- I_{class} = number of inputs per pixel of the classical method,
- I_{prop}, O_{prop} = number of I/O for our method.

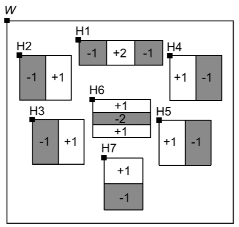
Measured acceleration:

Exam.	Meth.	I/O	t (ms)	Acceleration Theor.	Acceleration Meas.
SURF	Class.	32/0	664	1.65	1.63
	Prop.	14/5	407		
FACE	Class.	22/0	409	1.35	1.36
	Prop.	13/3	300		

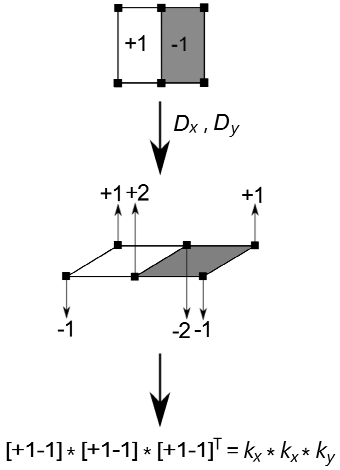
Haar-like features in scanning window

Input :
2nd order derivatives of HLFs

Example configuration

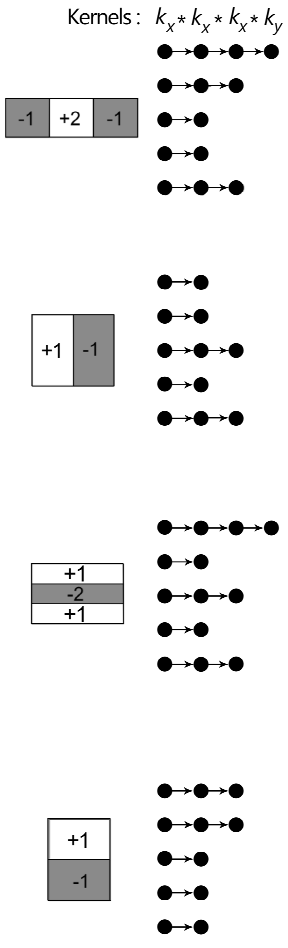


Derivates of HLF



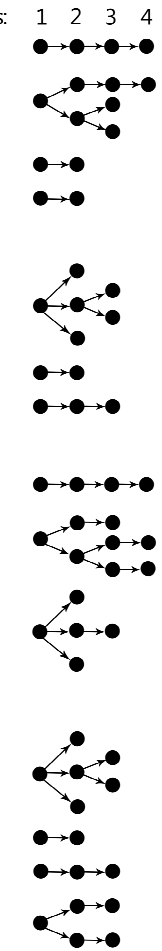
Decomposition into simpler kernels

Decompose HLFs into horizontal k_x and vertical k_y kernels forming convolution passes.



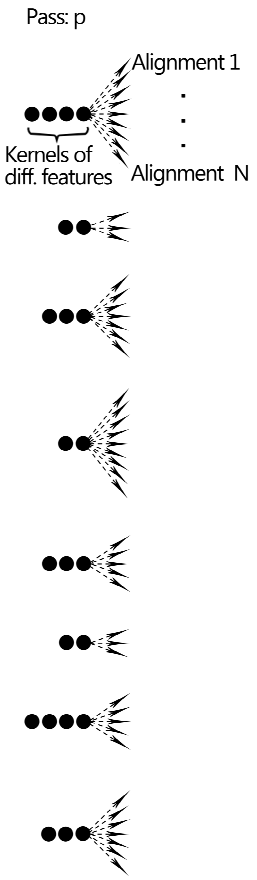
Assignment of kernels into passes

Permute kernels to convolution passes and order them into trees by testing if simpler kernels are **shared** across features.



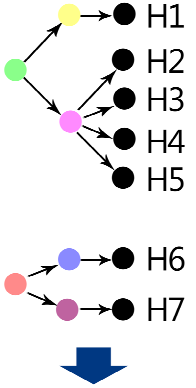
Alignment of kernels within passes

Align kernels across features so that their inputs always coincide in at least one position.



Best ensemble of kernel trees

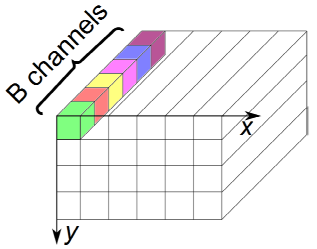
Keep the ensemble which yields **minimum I/O.**



Implementation of best ensemble: *B*-channel buffer

Store the outputs of the ensemble in an **array of contiguous elements.**

☞efficient memory caching



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Contact: Daniel.Wesierski@Telecom-SudParis.eu Website: www-public.Telecom-SudParis.eu/~wesiersk