Thinking Beyond the Block

Block Matching for Copy–Move Forgery Detection Revisited

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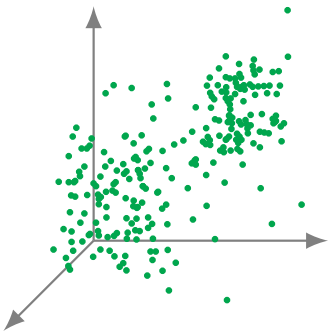
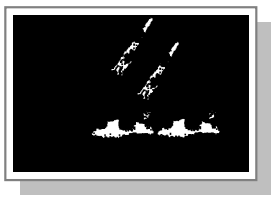
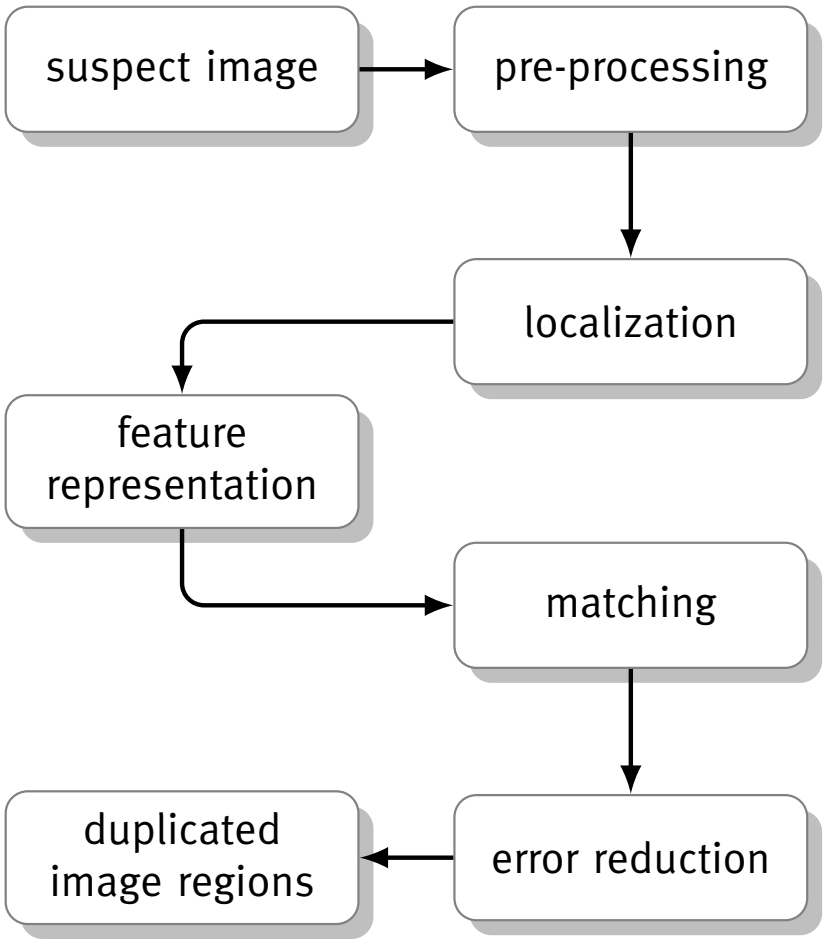
IS&T/SPIE Media Watermarking, Security, and Forensics
San Francisco, CA | February 9, 2015

Yet Another Paper CMFD Paper?

- general detection/localization procedure since 2003 [Fridrich et al. 2003]





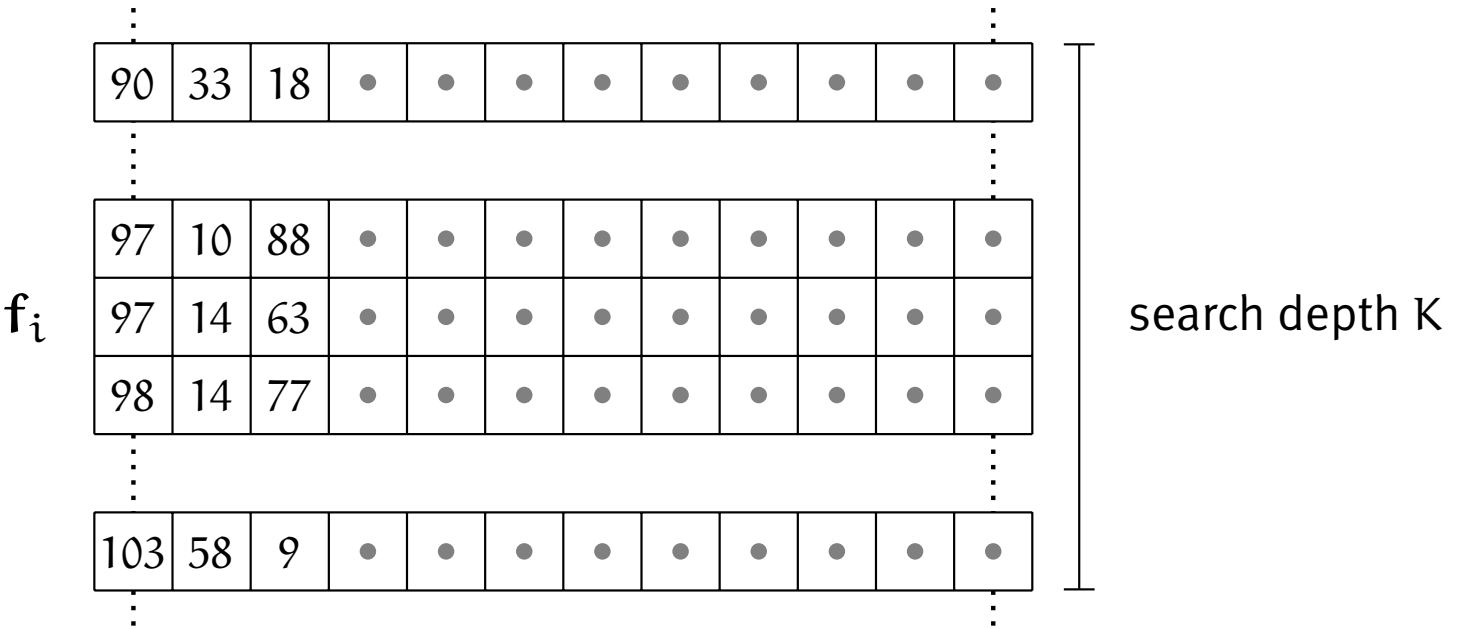


- color space transforms
- saturated regions
- overlapping blocks
- key points (SIFT, ...)
- find similar blocks / key points in the feature space
- remove false positives

Lexicographic Matching

- lexicographic sorting of feature vectors
- compare i-th sorted vector to K neighbors

[Fridrich et al. 2003]



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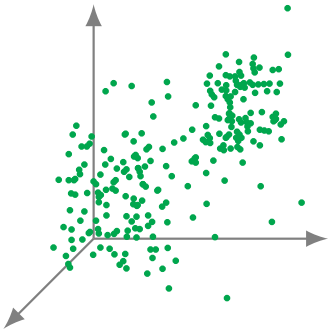

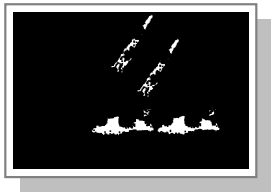

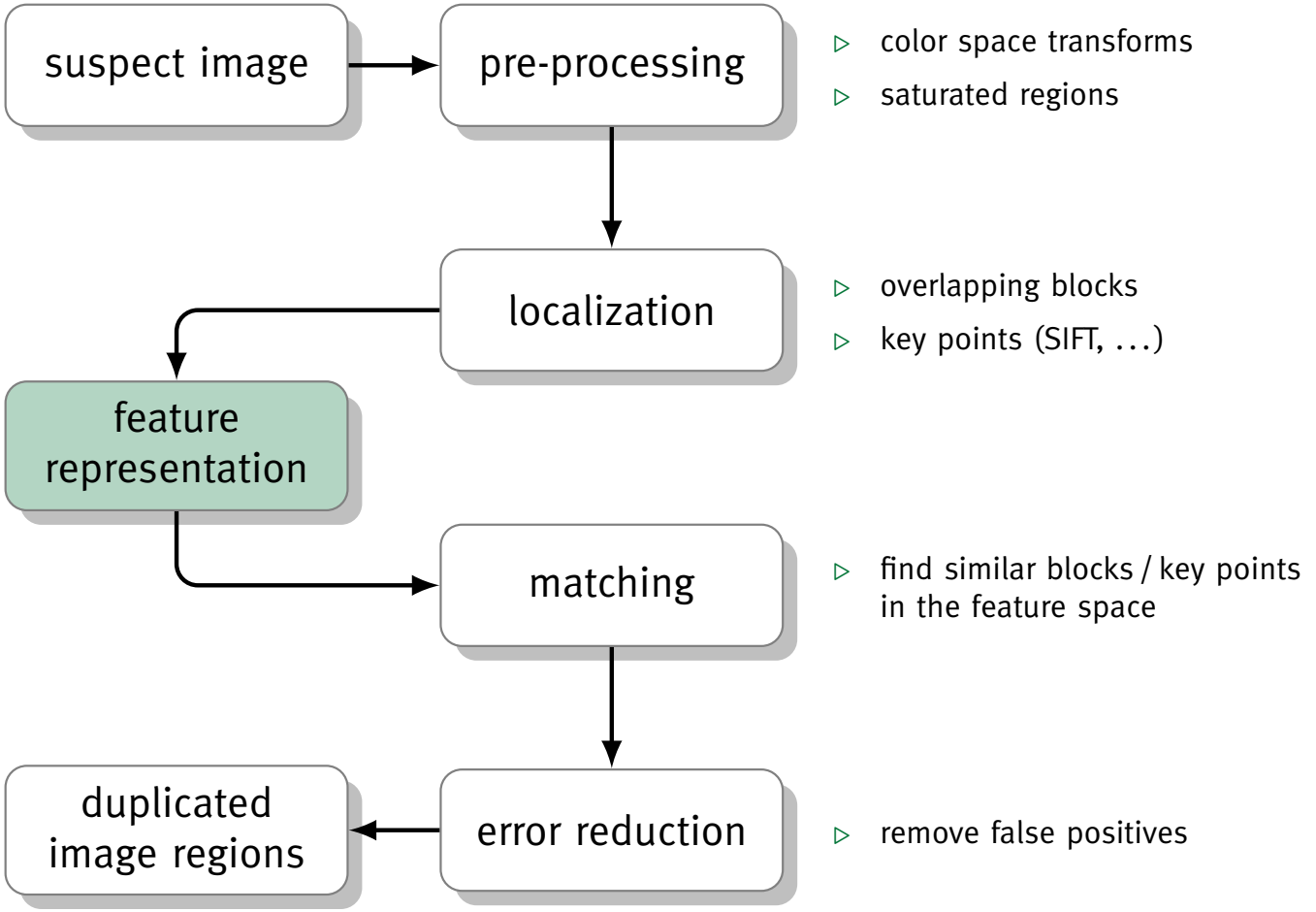

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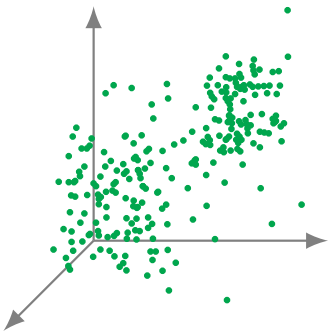

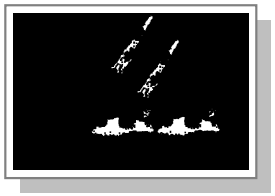

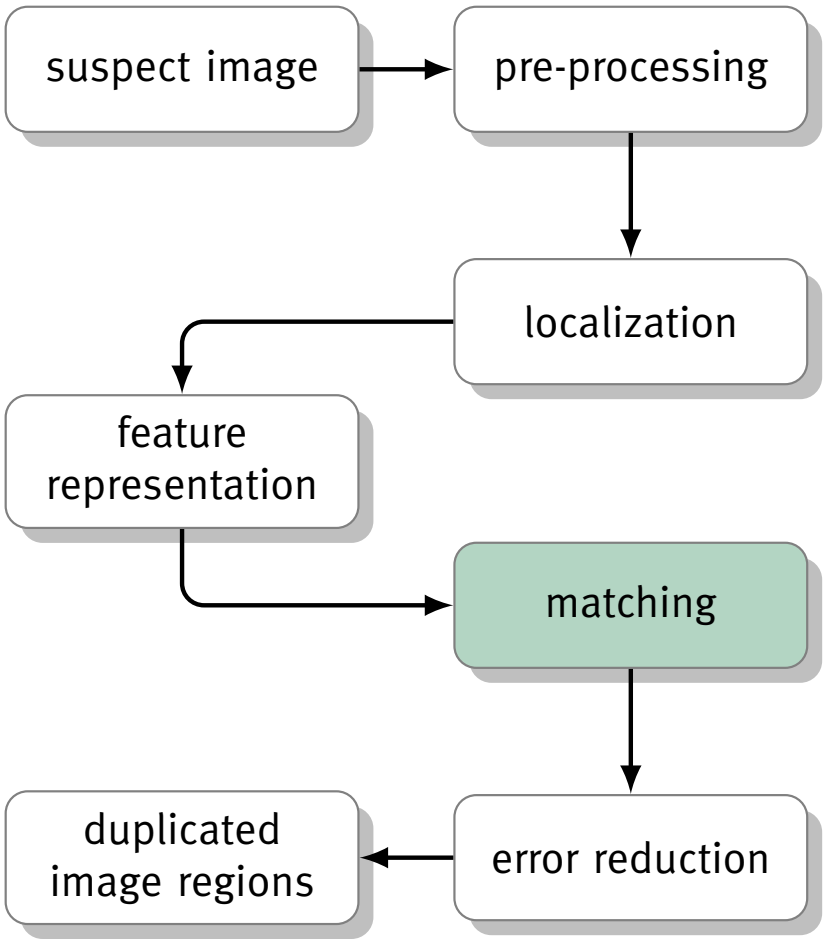

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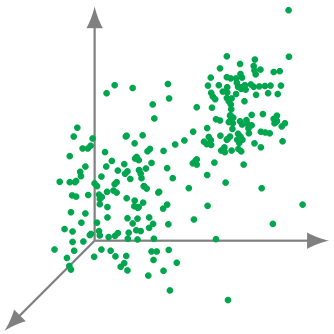

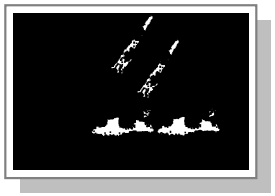

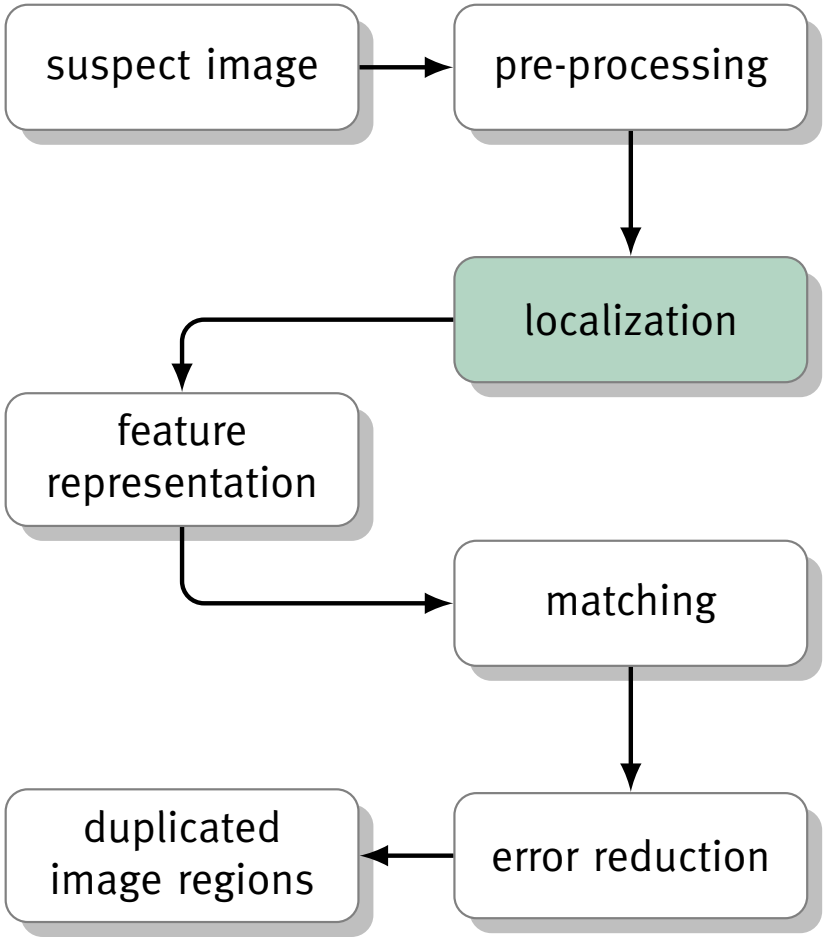

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Block-Based?

- reported typical runtimes (single-thread)

	blocks (Zernike moments)	SIFT	
GRIP database (0.75 MP)	54 s	4 s	[Cozzolino et al. 2014]
Erlangen database (8 MP)	4900 s	126 s	[Christlein et al. 2012], matching step only

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GRIP DB image TP_C01_013

blocks

SIFT

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GRIP DB image TP_C01_013

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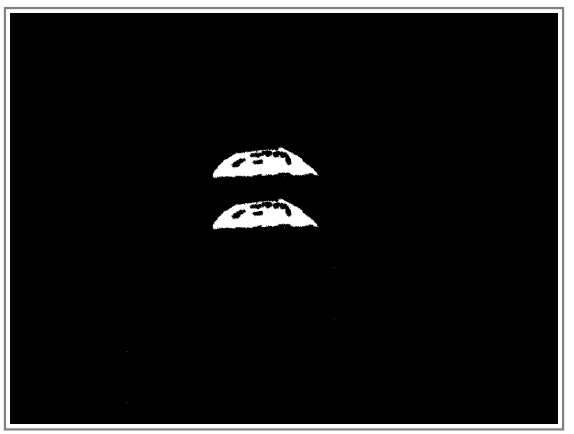
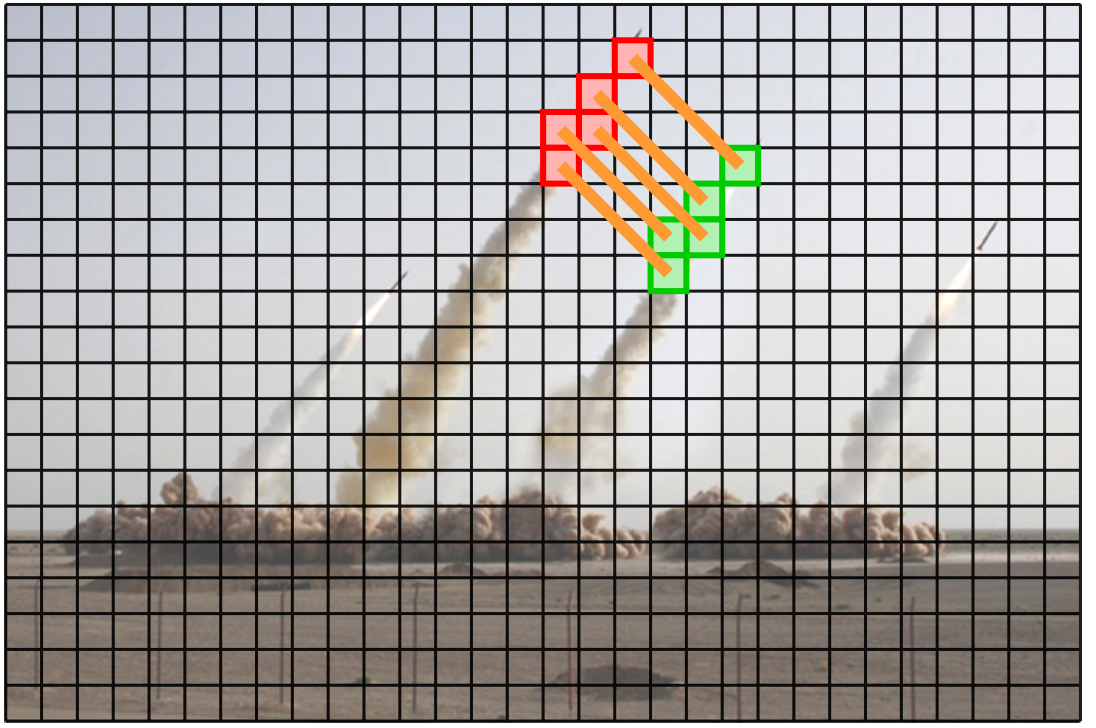


block-based kD tree matching is the method of choice for most accurate CMFD

Working Assumptions

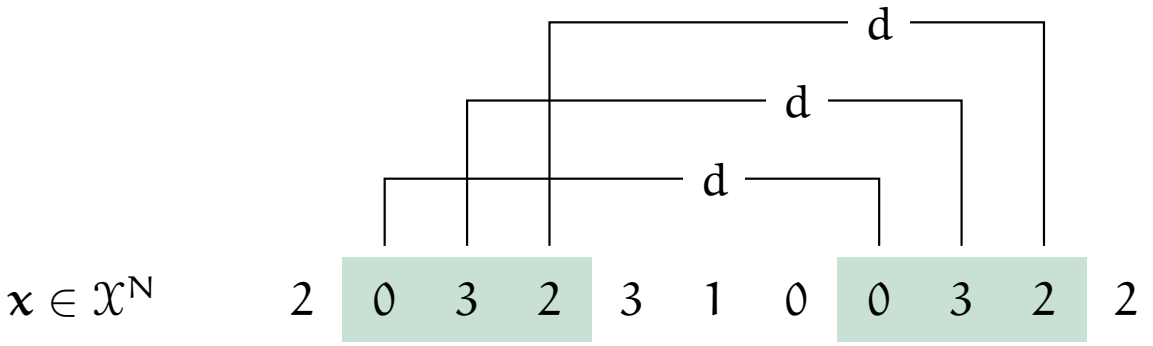


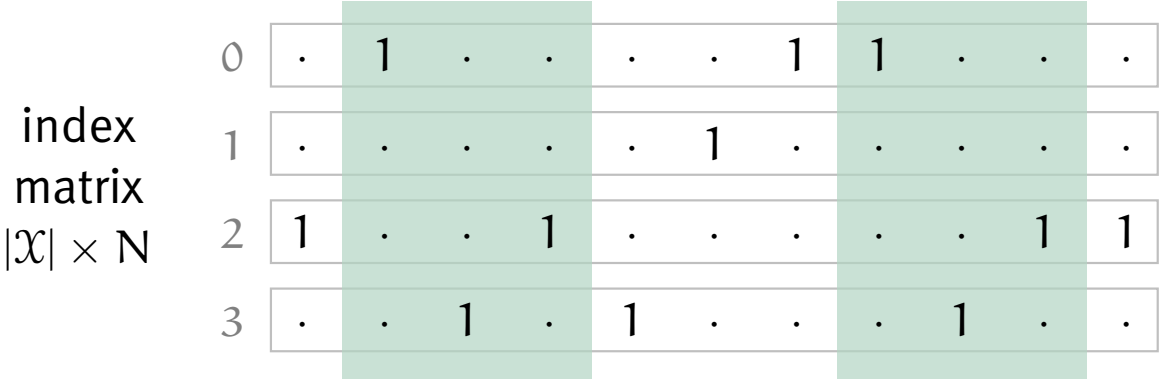
- copied regions are spatially connected subsets of feature vectors $\{\mathbf{f}_i\}$
- we focus on rigid translations only
- feature vectors can be quantized to integers, $\mathbf{f}_i \mapsto \mathbf{x}_i \in \mathbb{N}$

goal

- find *all* repeated occurrences of connected patches of integers

Bit Twiddling For One Dimension





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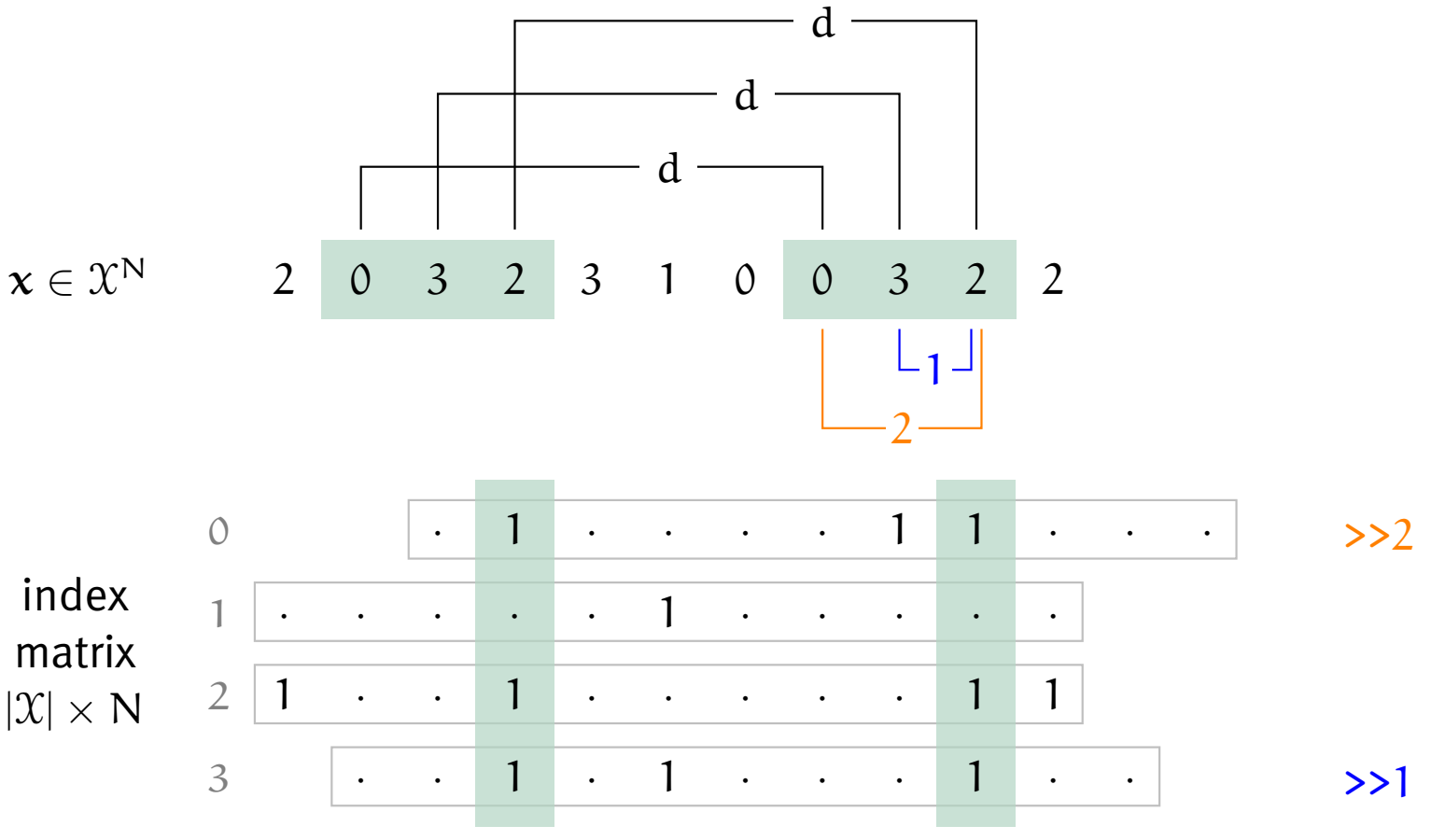

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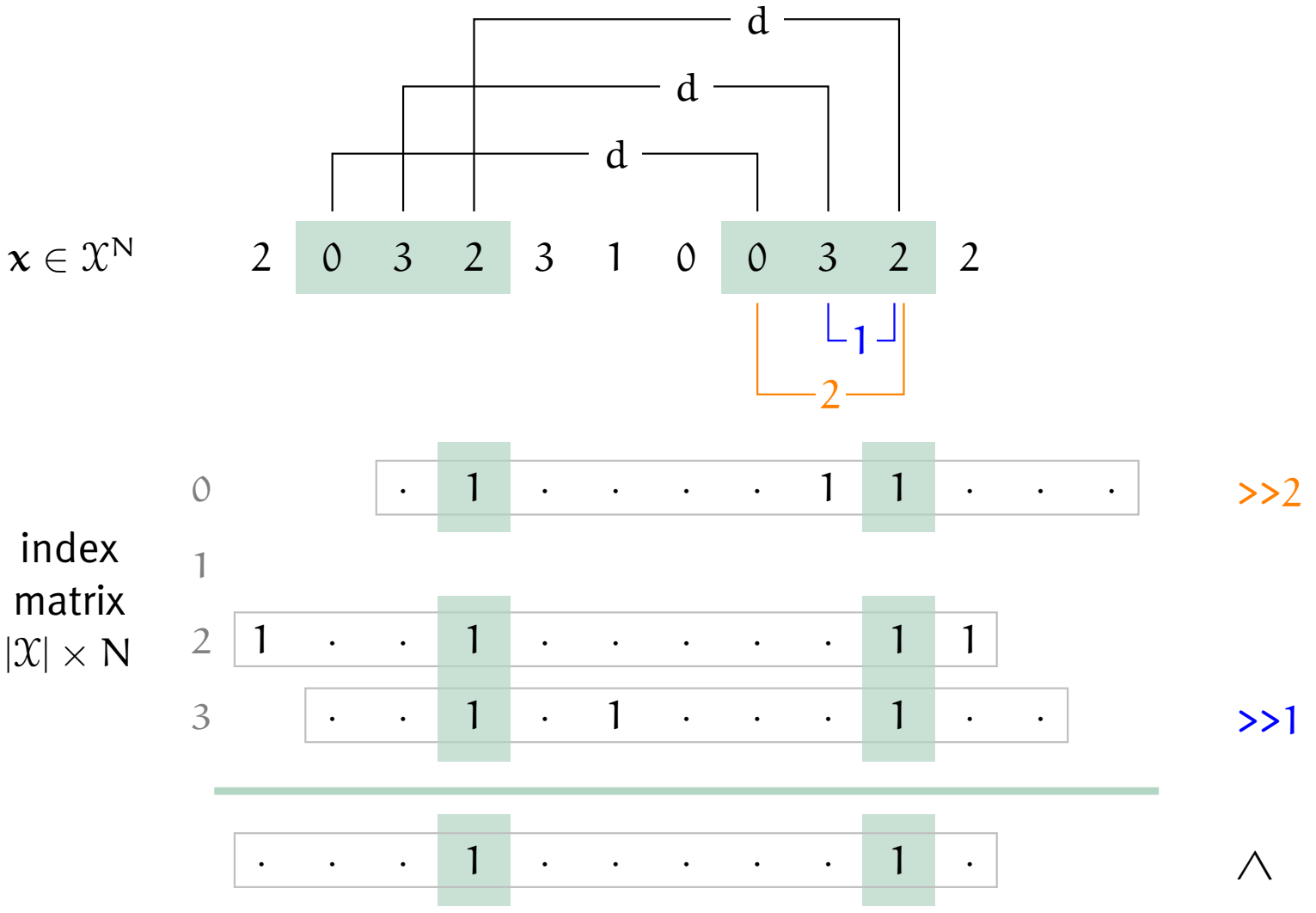

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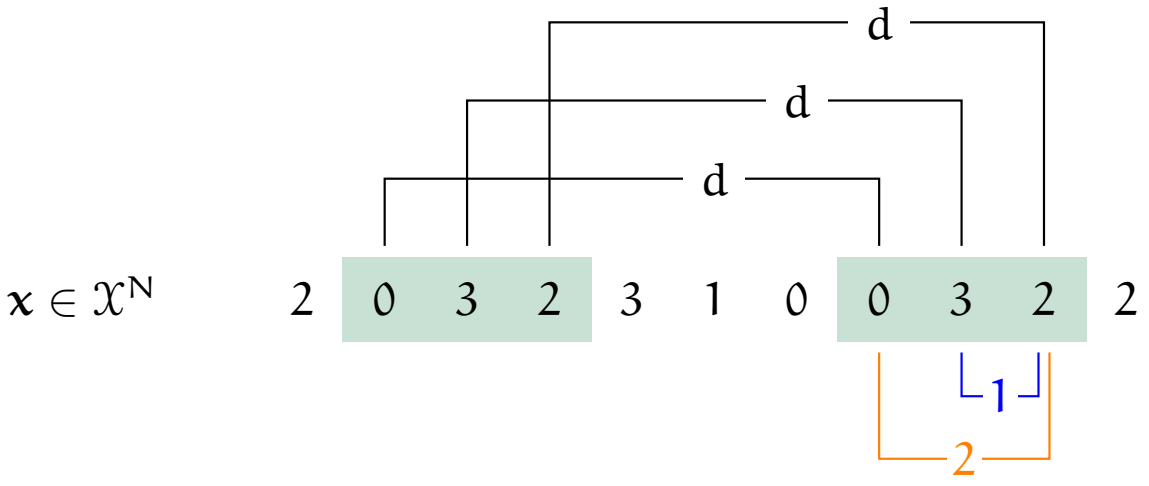
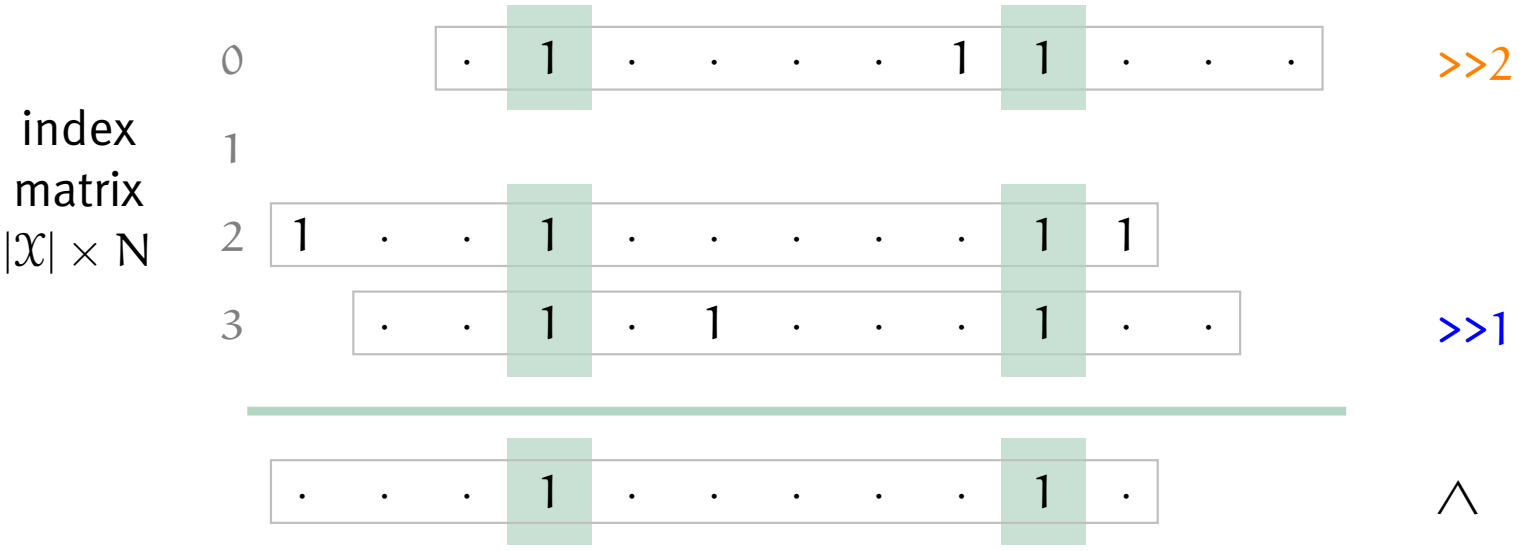
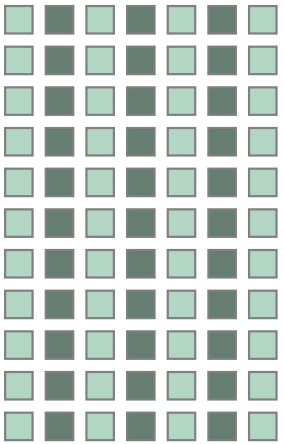


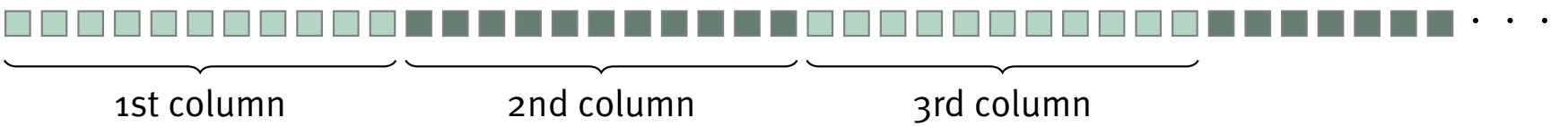
- shift/AND for all blocks
- re-use earlier shifts
- buffer columns for non-unique elements



Extension to 2D



- column-major vectorization of the input



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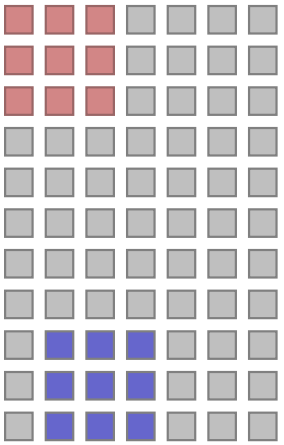
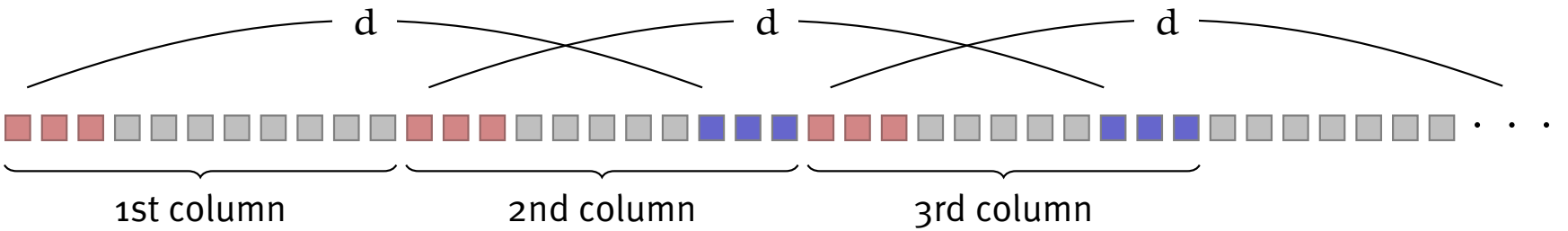


- column-major vectorization of the input to find duplicate $w \times 1$ patches



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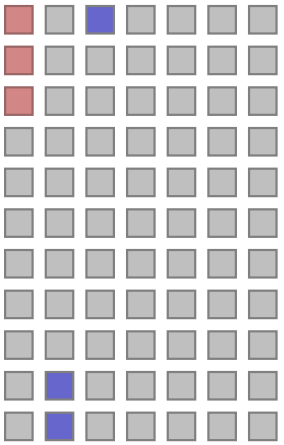
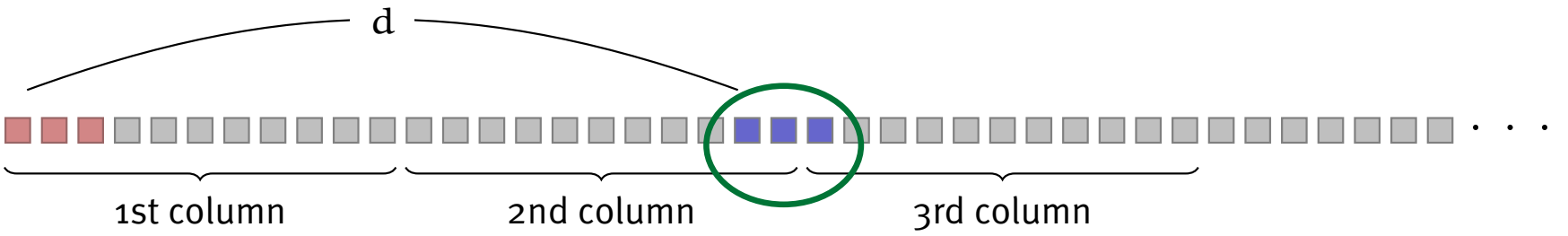


- column-major vectorization of the input to find duplicate $w \times 1$ patches
- special treatment of border elements



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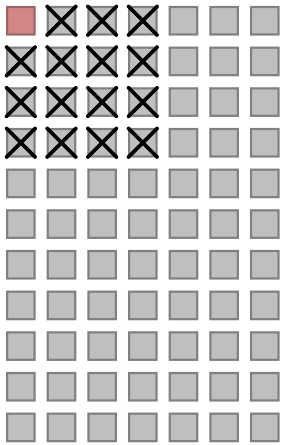

- column-major vectorization of the input to find duplicate $w \times 1$ patches
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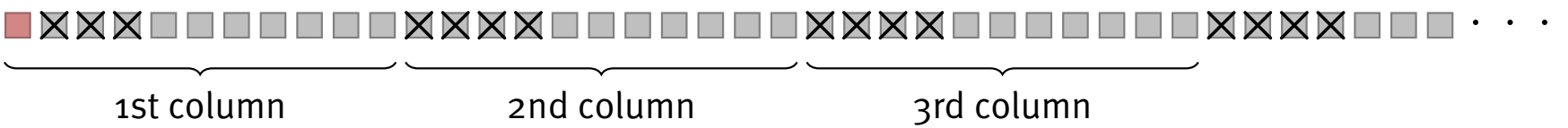
- varying masks for spatially inadmissible patches



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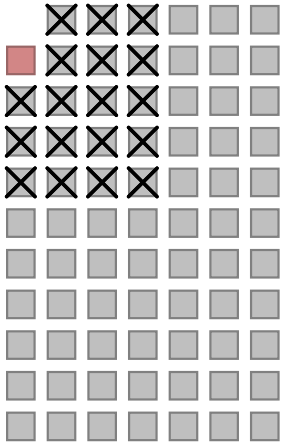

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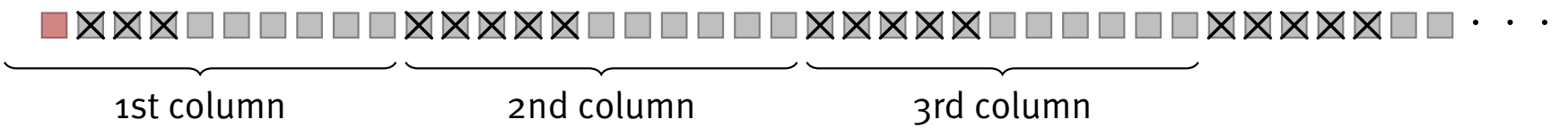

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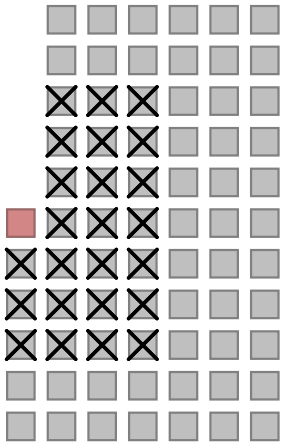

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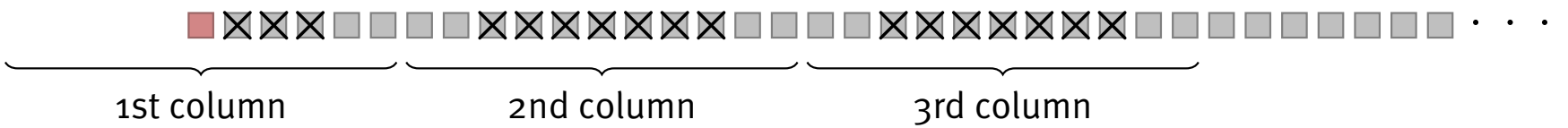
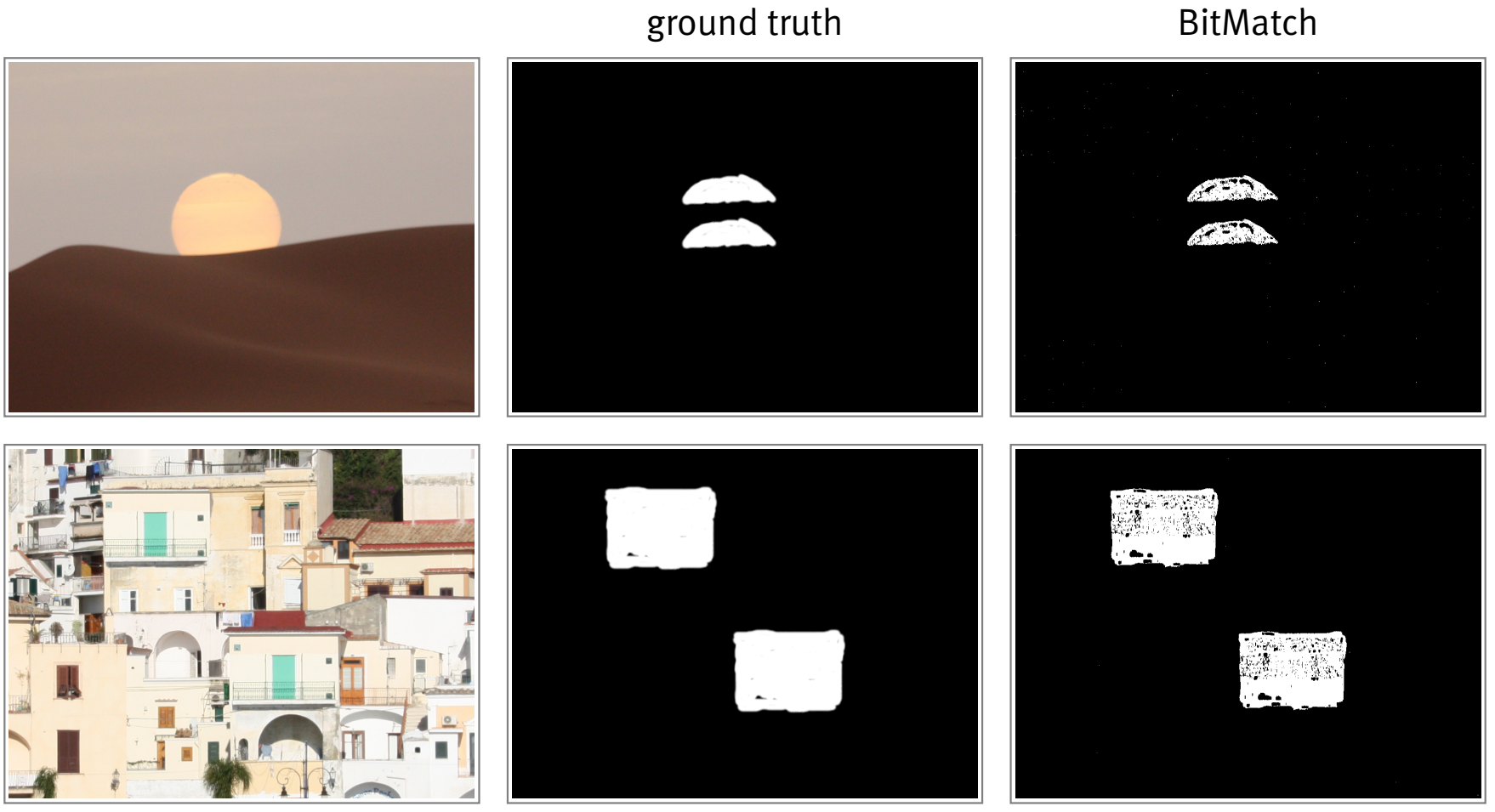


Typical Results

GRIP-UNINA Database, intensity-based exact matching, 5×1 patches



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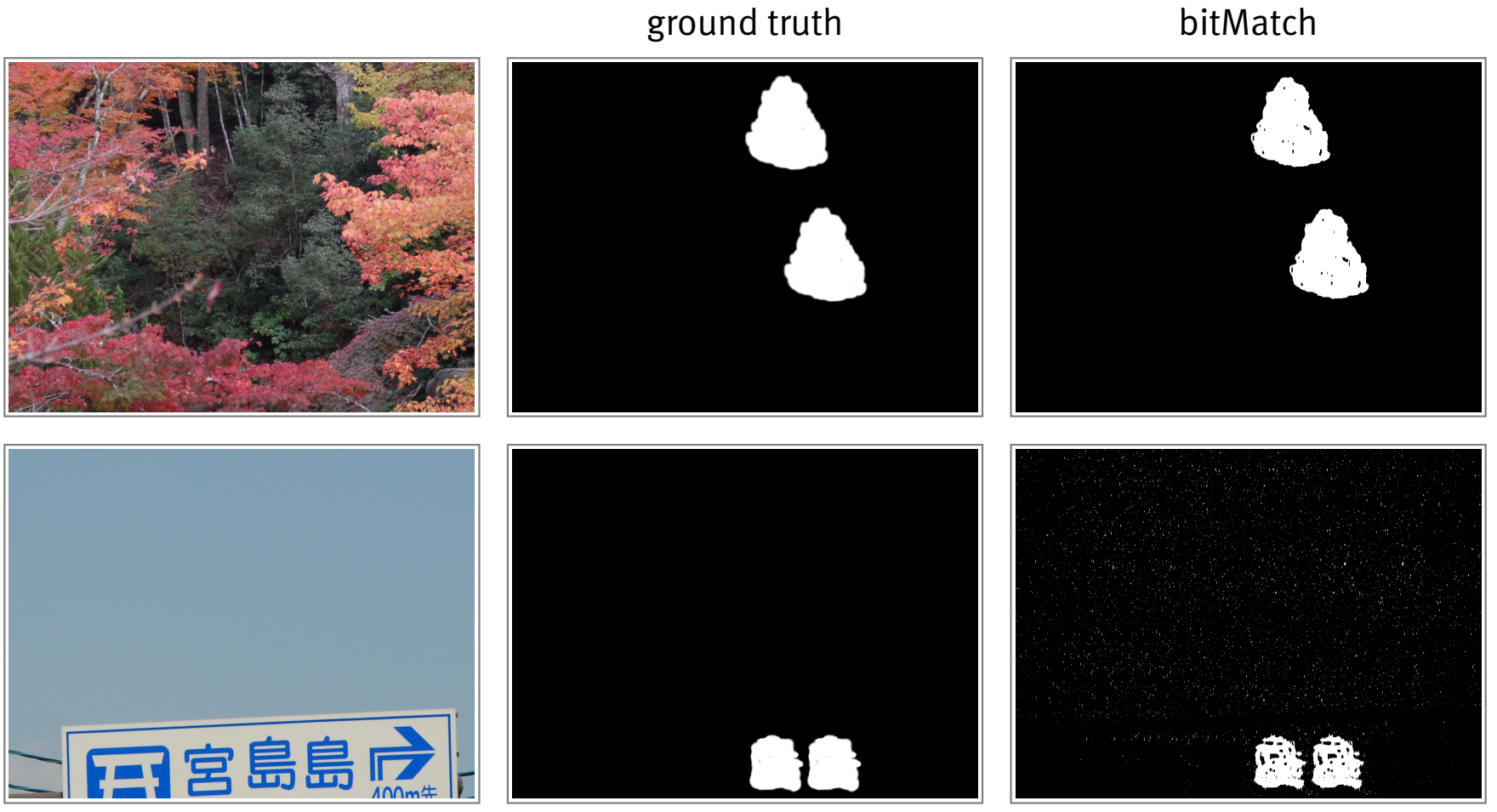
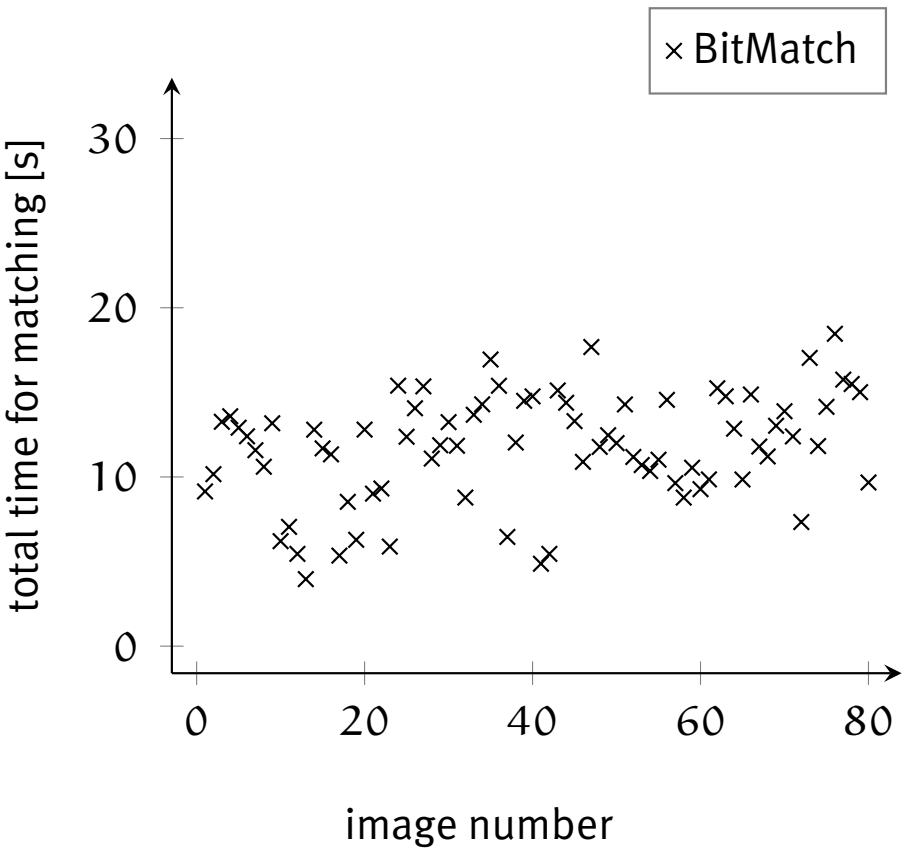


Quantitative Results

The Rise of Lexicographic Matching



GRIP-UNINA Database

F-measure: $F = \frac{2TP}{2TP + FP + FN}$

	F-measure	runtime
BitMatch	0.9487	11.71598

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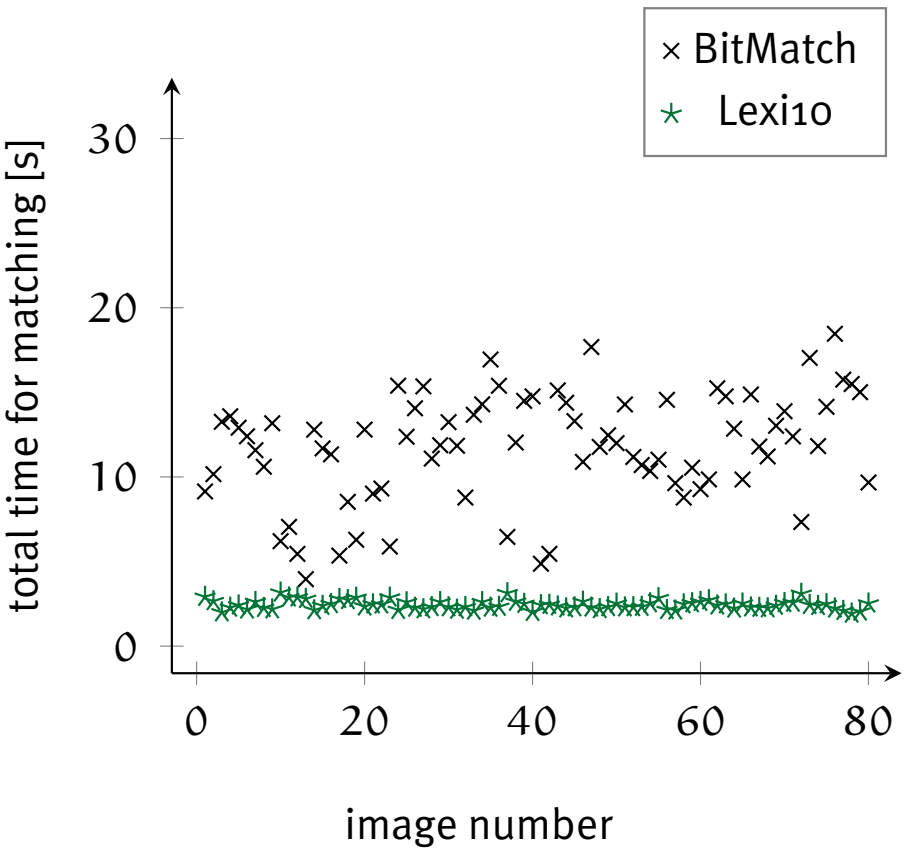

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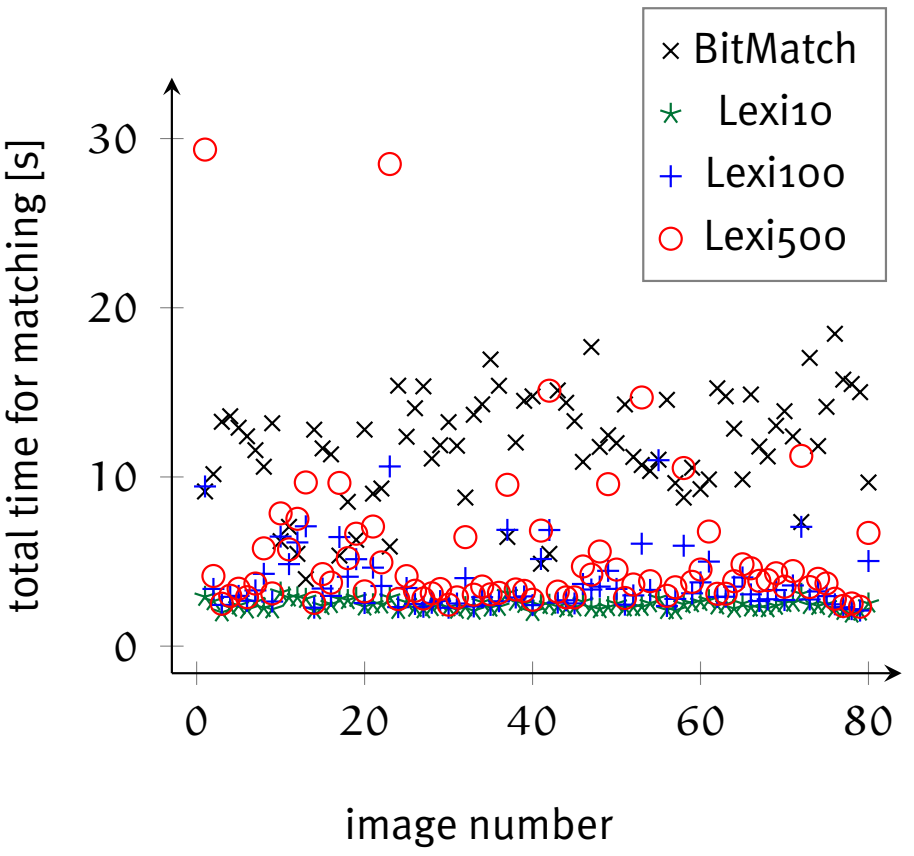

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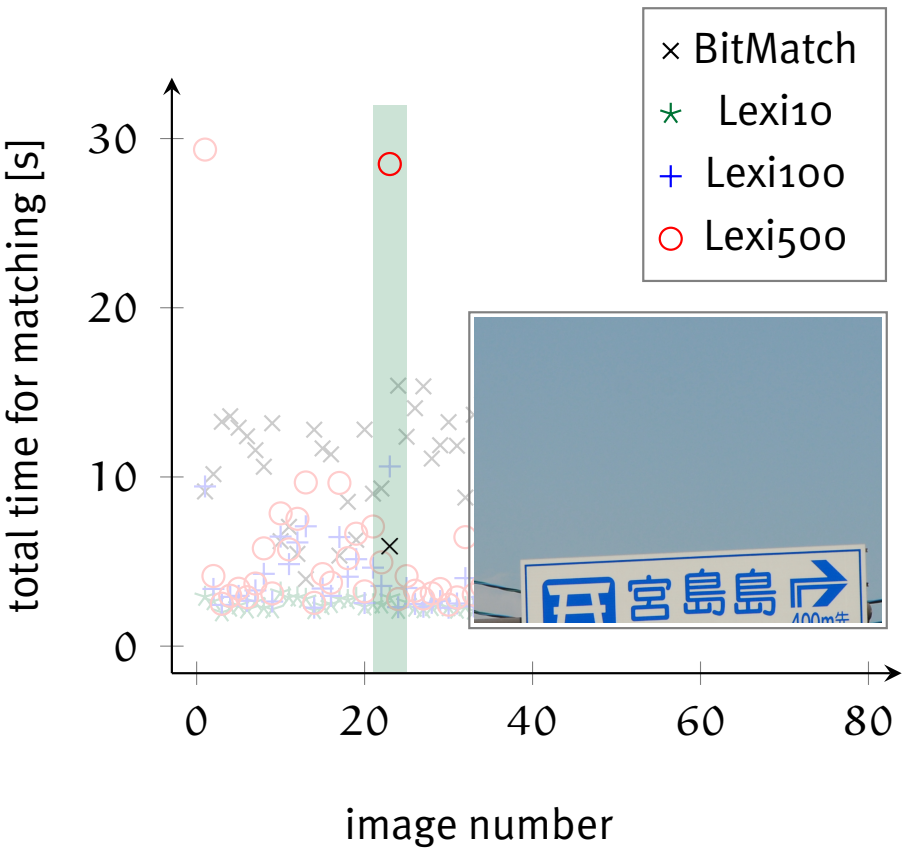

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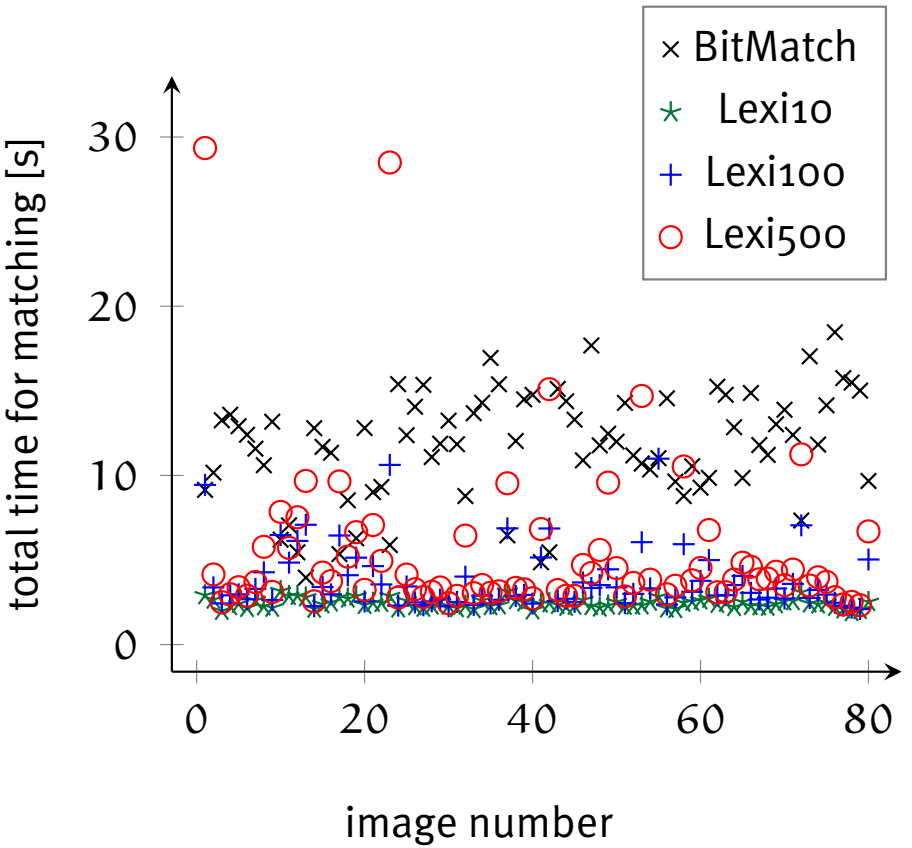
The Fall of BitMatch



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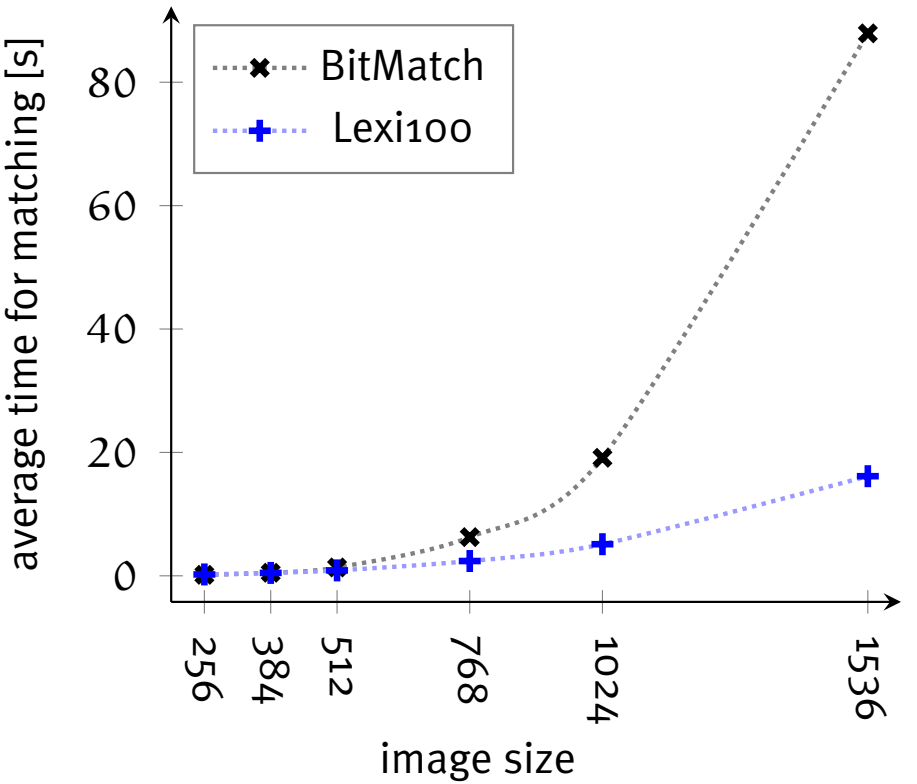
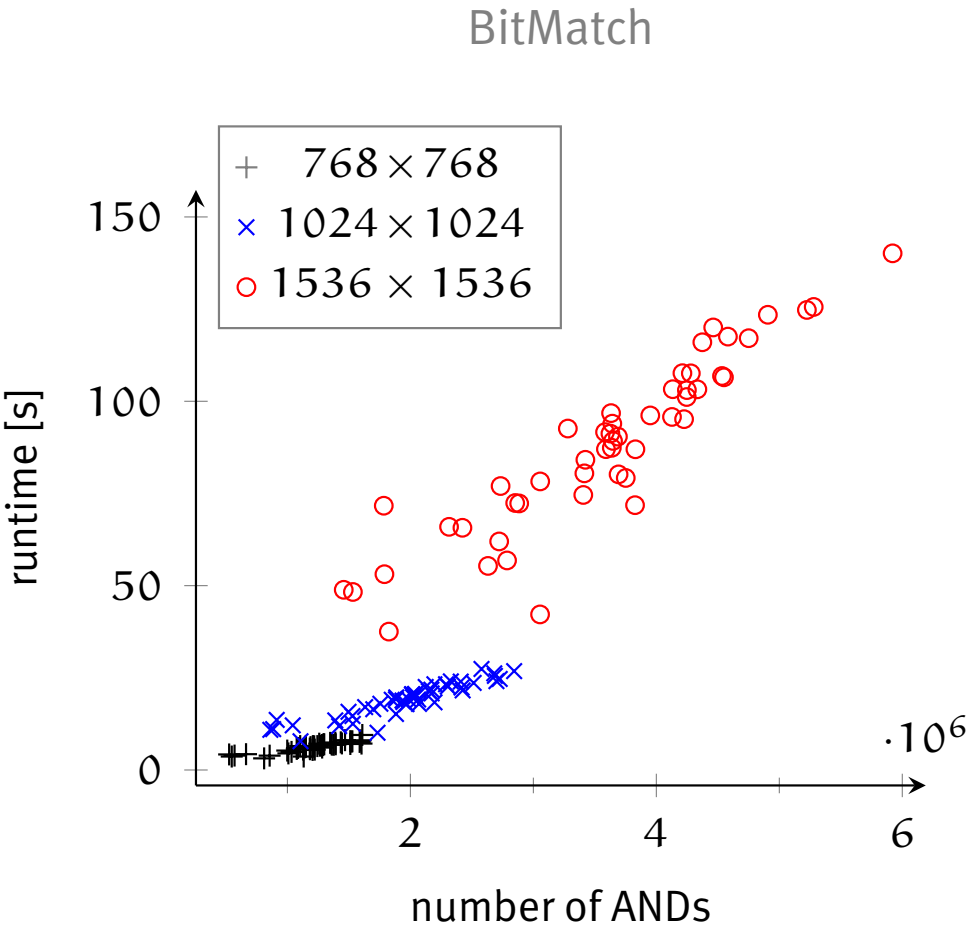


Dresden Image Database

Bottlenecks



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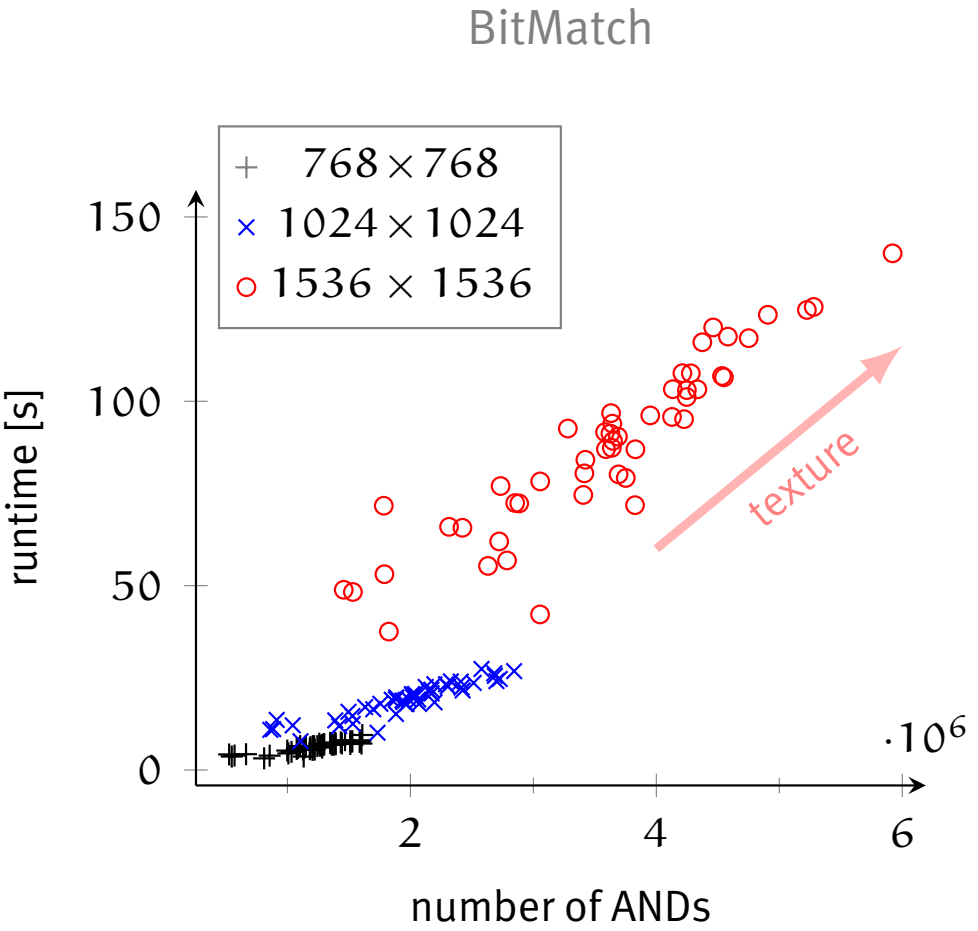

Bottlenecks

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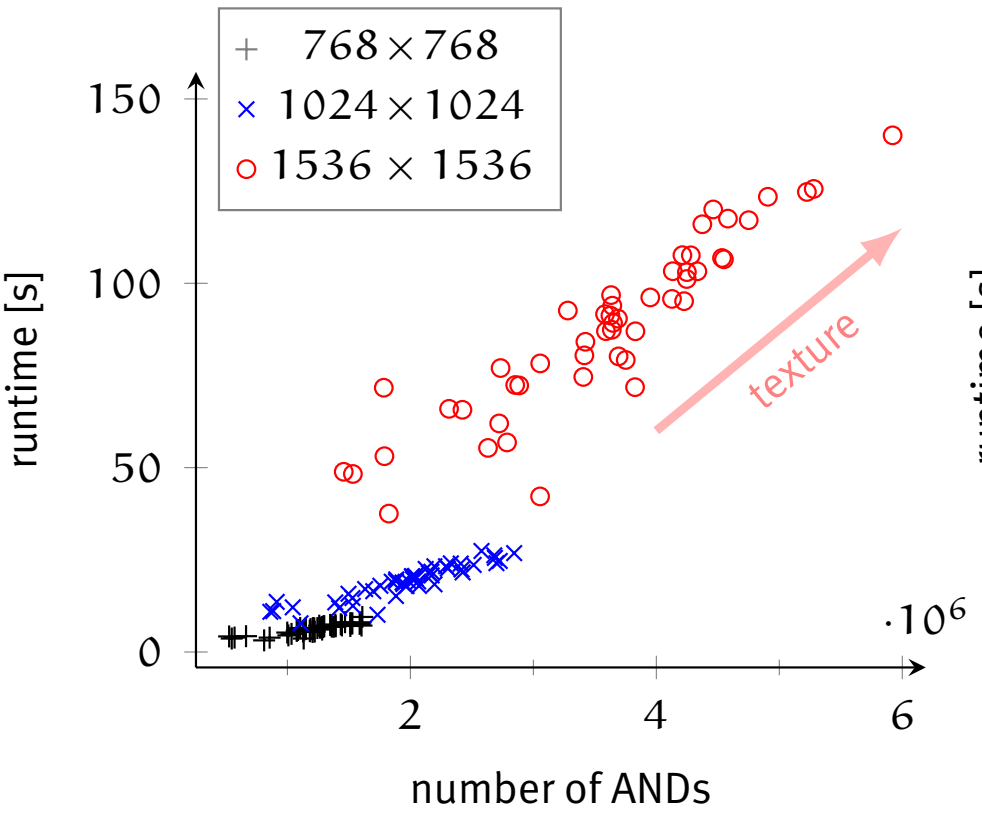
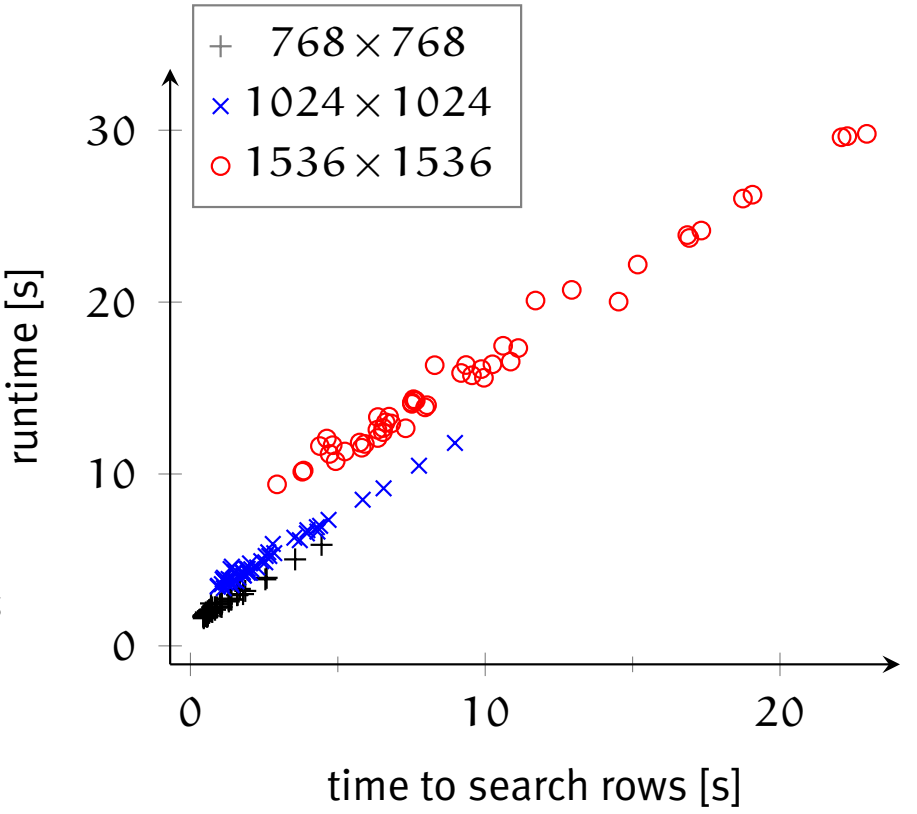


lexicographic matching



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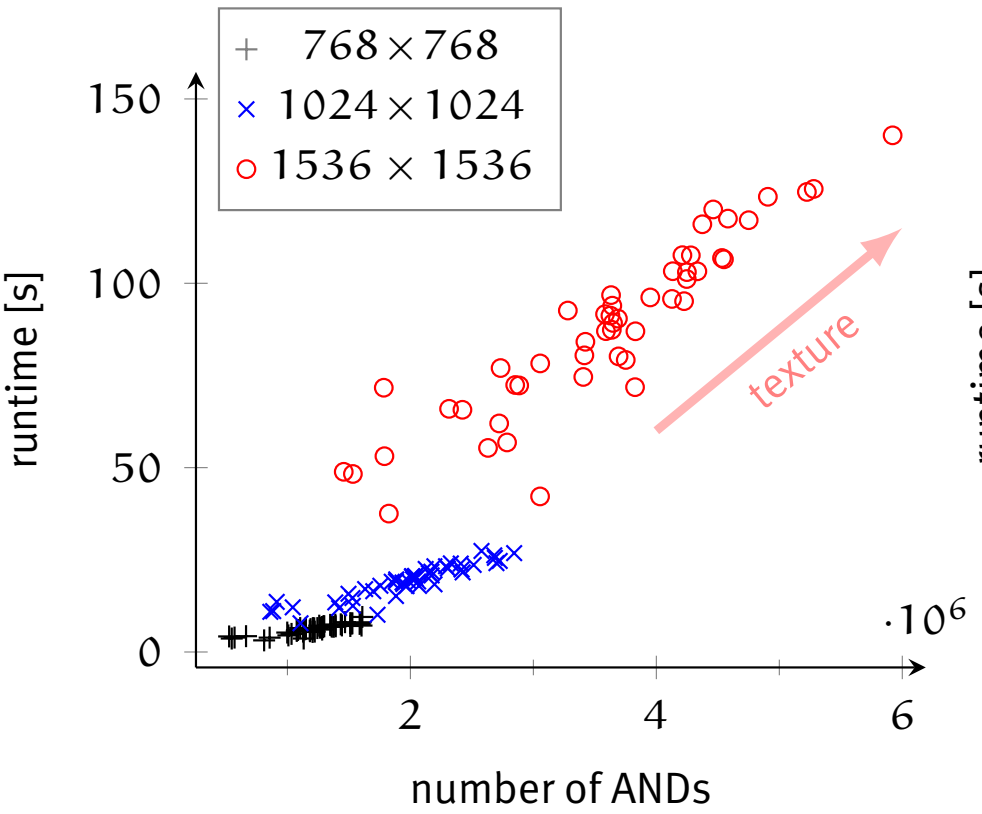

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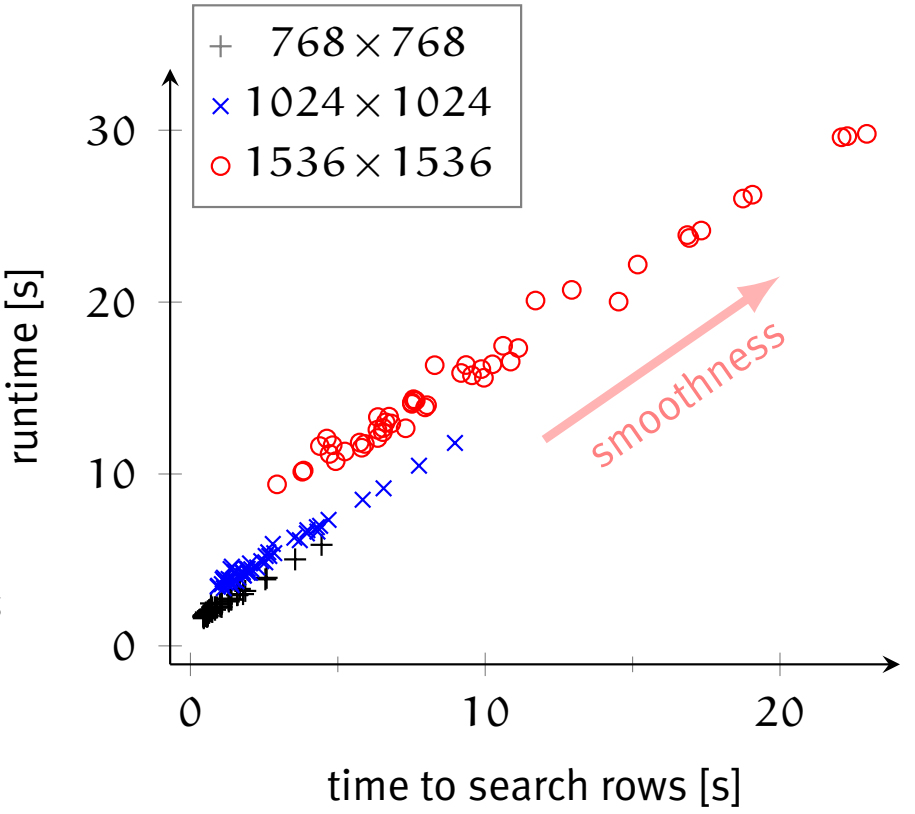
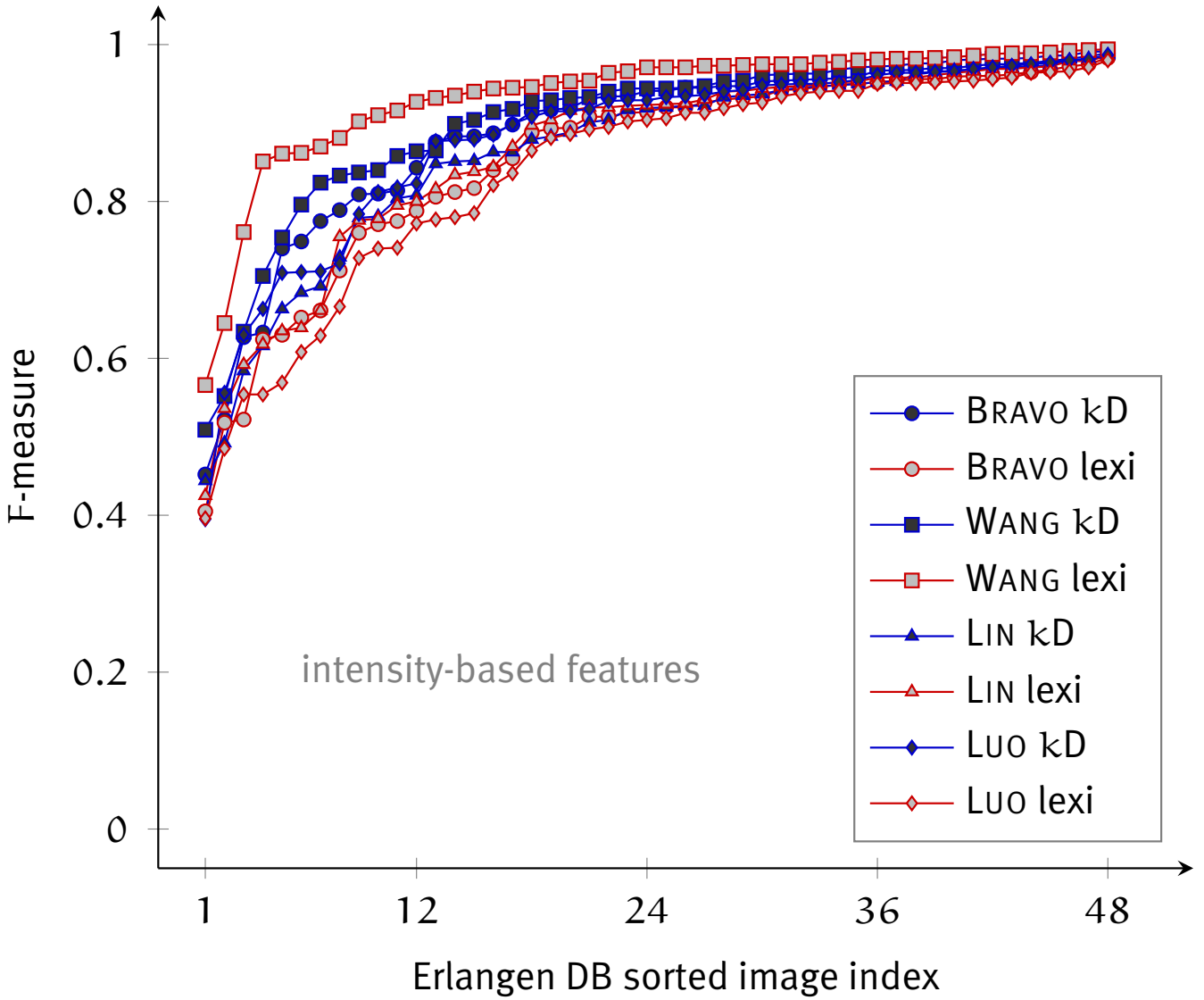
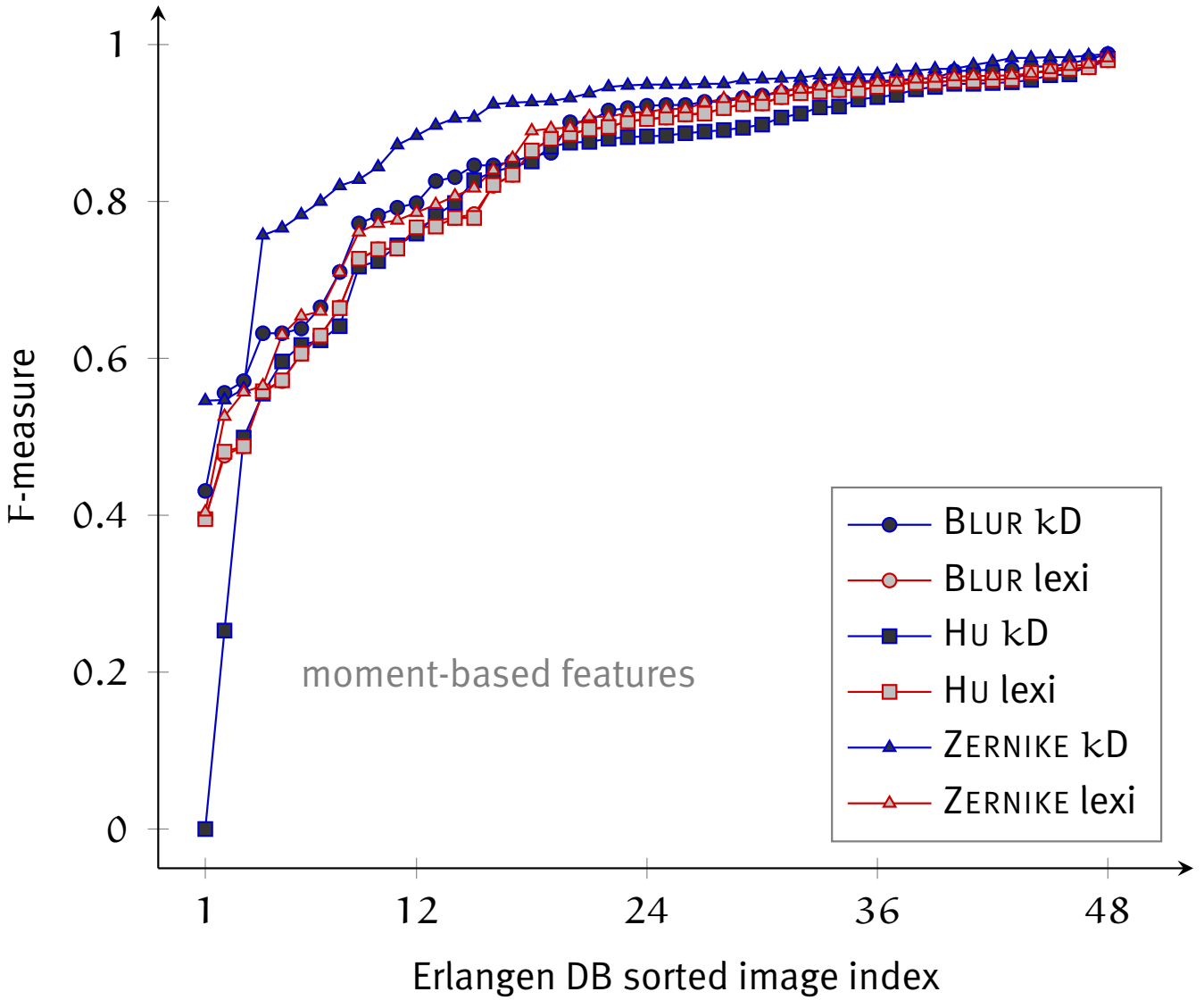


Back to the Roots



16×16 blocks
$\geqslant 800$ equal shifts

Back to the Roots



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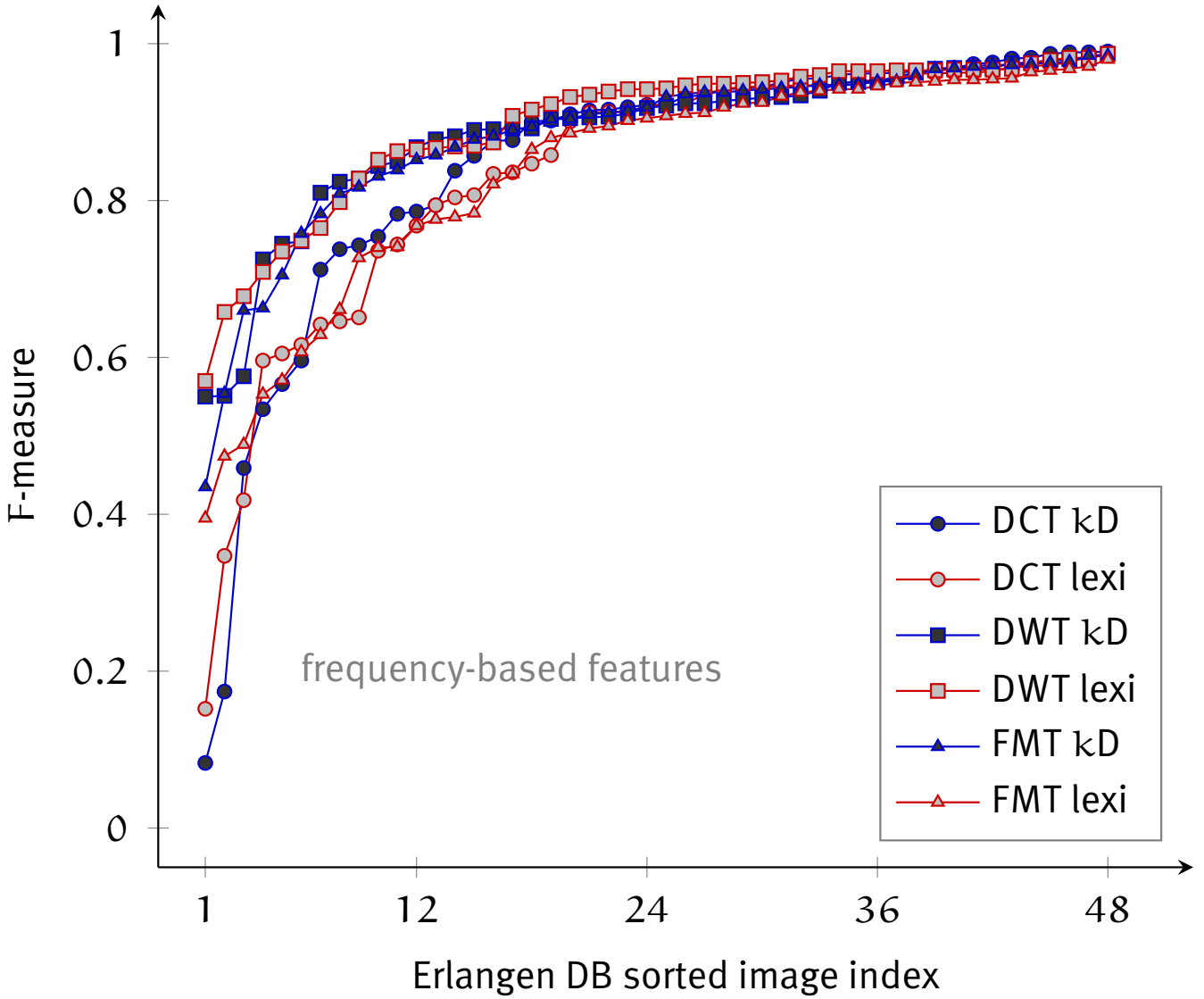

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Summary

BitMatch

- replace feature-matching with index-based bit-wise operations to find *all exact* duplications

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- source code available: `ws.binghamton.edu/kirchner`

Thinking Beyond the Block

Block Matching for Copy–Move Forgery Detection Revisited

Matthias Kirchner — Binghamton University
Pascal Schöttle — University of Münster
Christian Riess — Stanford University

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