THE TREE OF SHAPES TURNED INTO A MAX-TREE: A SIMPLE AND EFFICIENT LINEAR ALGORITHM

A poster about mathematical morphology without formulas, and about an algorithm without code!

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At a Glance

Problem:

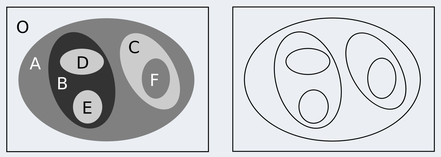
- the morphological tree of shapes (ToS) is a great structure...
- ...but its computation is not efficient enough

Solution:

- from a quasi-linear [1] to a linear algorithm
- an optimization to reduce memory footprint (DIV 4 in 2D, DIV 8 in 3D; not detailled here)

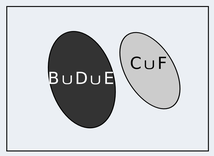
The Tree of Shapes (ToS)

Based on the connected components of all threshold sets:

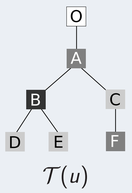


u

level lines of u



two shapes of u

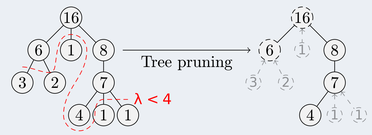


$\mathcal{T}(u)$

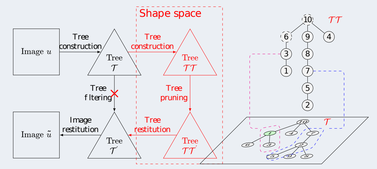
Invariant to:

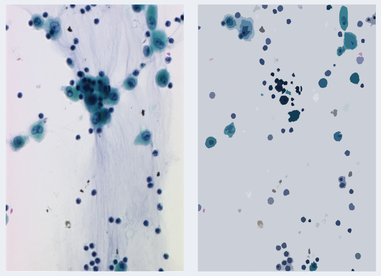
- contrast changes
- contrast inversion
- some local illumination changes

Applications of the Tree of Shapes

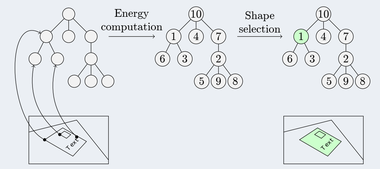


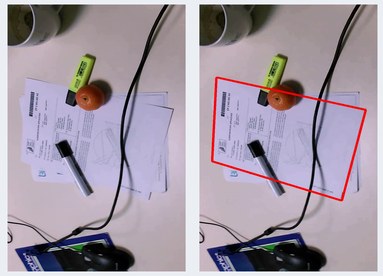
grain filter



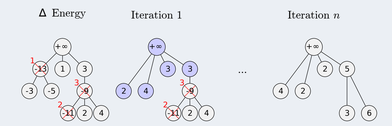


filtering in shape-space





object detection



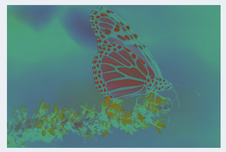
simplification / segmentation

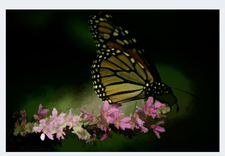
Taking benefits of properties of this tree structure...

Great for IP, PR and CV

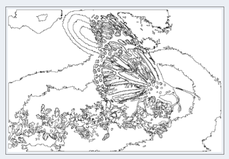
original

modified #1





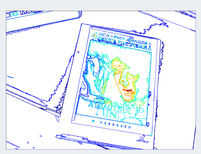
modified #2

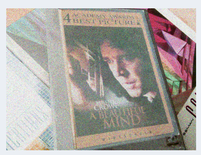


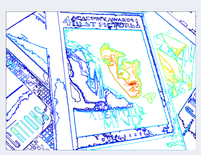
same level lines!

Robustness to changes

2 images ▼

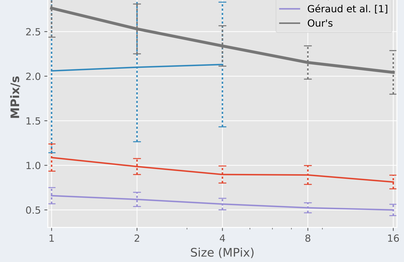






their meaningful level lines ▲

...in a fast way



(Tested on 8 20-MPix natural images, single-thread with a laptop configuration)

Selected bibliography

[1] T. Géraud *et al.*, "**A quasi-linear algorithm to compute the tree of shapes of *n*D images**," in *ISMM*, pp. 98–110, vol. 7883 of LNCS, Springer, 2013.

[2] E. Carlinet and T. Géraud, "**MToS: A tree of shapes for multivariate images**," *IEEE Transactions on Image Processing*, vol. 24, num. 12, pp. 5330–5342, 2015.

[3] —, "**A comparative review of component tree computation algorithms**," *IEEE Transactions on Image Processing*, vol. 23, num. 9, pp. 3885–3895, 2014.

[4] S. Crozet and T. Géraud, " **A 1st parallel algorithm to compute the morphological tree of shapes of *n*D images**," in *IEEE ICIP*, pp. 2933–2937, 2014.

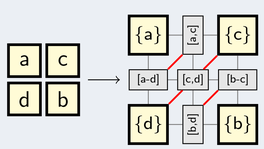
[5] U. Moschini *et al.*, "**A Hybrid Shared-Memory Parallel Max-Tree Algorithm for Extreme Dynamic-Range Images**," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 40, num. 3, pp. 513–526, 2017.

[6] M. Götz *et al.*, "**Parallel computation of component trees on distributed memory machines**," *IEEE Transactions on Parallel and Distributed Systems*, online preview, 2018.

NEW ALGORITHM

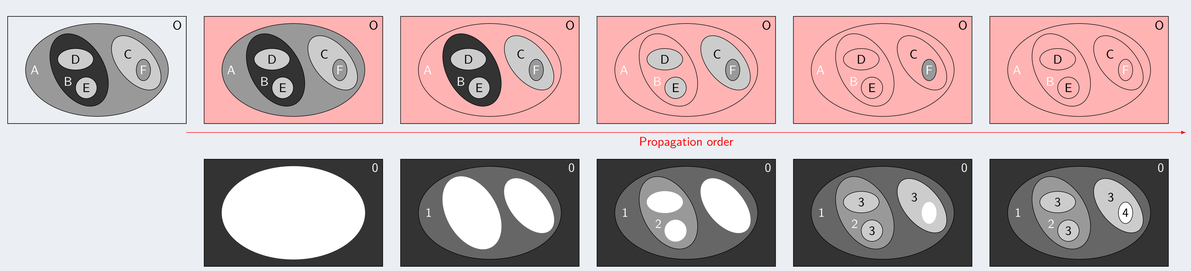
Key idea: ToS(image) = max-tree(depth-map(image))

1st stage: immersion



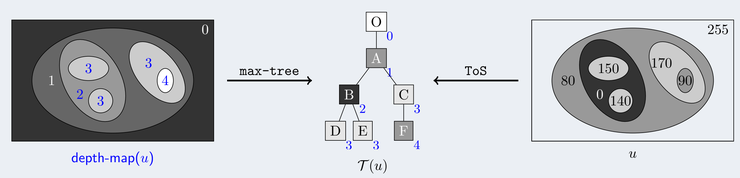
- we need to pass between pixels
  ⇝ Khalimsky grid
- and with different values
  ⇝ interval-valued map

2nd stage: depth-map construction



- propagate continuously (both in space and in gray-scale) from the boundary, and number pixels
- such a propagation can be parallelized [4]

3rd stage: max-tree computation



- the max-tree can be computed very very fast [3]
- with distribution and/or parallelization [5, 6]

the ToS exists for multi-variate data (color images, multi-modality images, multi-band images...) [2]

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