Getting a Morphological Tree of Shapes for Multivariate Images: Paths, Traps, and Pitfalls

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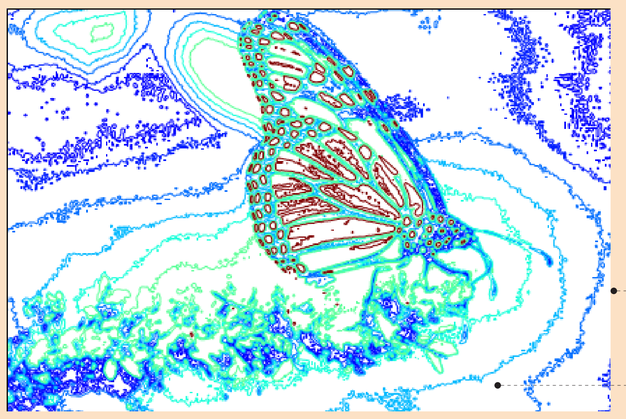
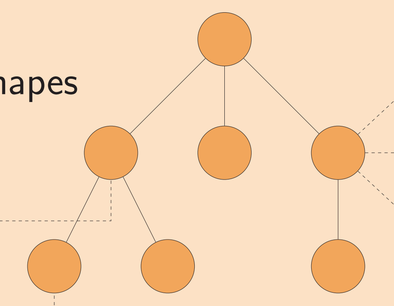
Level lines representation ≡



Tree of Shapes ≡



Featuring

- Connected components without holes
- Self duality
- Many morphological invariances

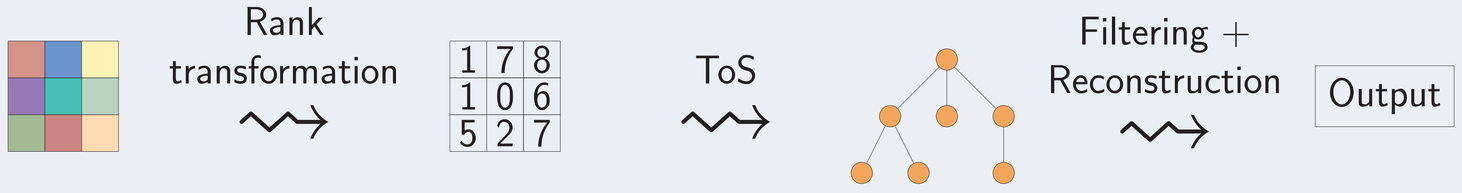
Extra materials: http://publis.lrde.epita.fr/carlinet.14.icip

At a Glance

- **Motivation.** The Tree of Shapes (ToS) provides a *high-level representation of the image structure* and has *many applications* (here, grain filter = denoising).
- **Objective.** Extend the ToS computation on color images.
- **Problem.** A natural tree **does not** exist for color images (it requires a total order).
- **Contribution.** Review of standard approaches and new leads to extend the ToS on colors and get a **single** structure representing the image.

Approach 1. Total (pre)order based Tree of Shapes (Standard)

Idea. Define a new **total** (pre)-order on colors.



Total (pre)order considered:

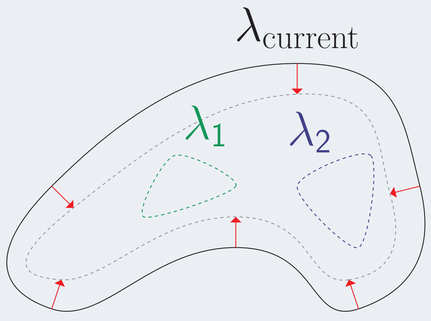
- Total order: lexicographical ordering
- Total pre-orders: luminance / chrominance in La*b*, RGB, HSL

Problems.

- Use an *arbitrary* choice of total ordering
- Many reconstruction policies with pre-orders that yield very different results (visible color artefacts)

Approach 2. Distance based Tree of Shapes (Standard)

Idea. Extend the ToS algorithm with a propagation to the closest level in the front.



In gray level. $\lambda_{next} = \lambda_{\text{current}} \pm 1$

Distance-based approach.

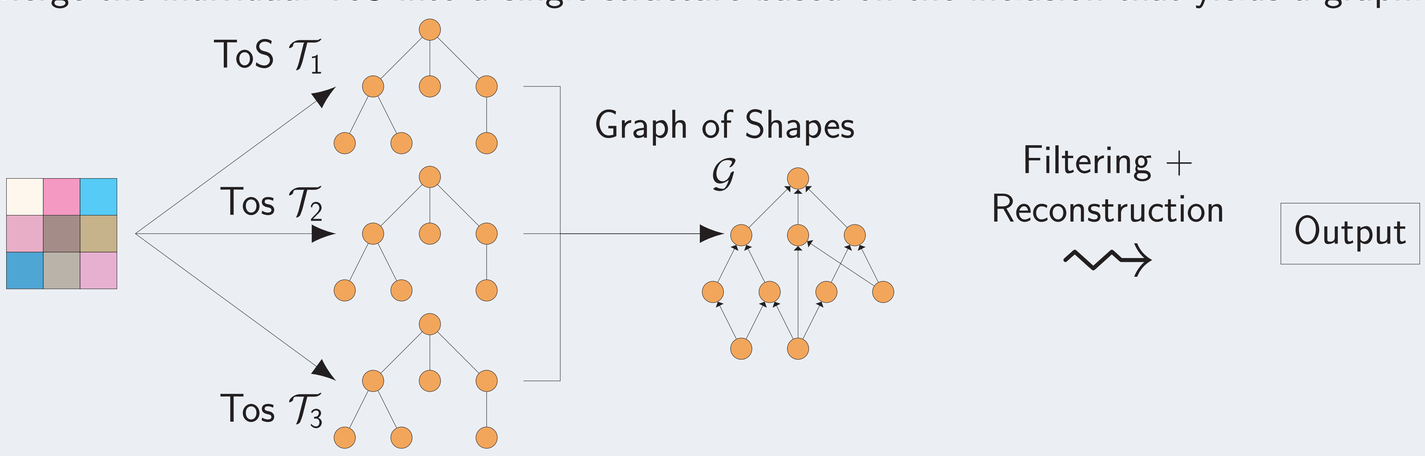
$$\lambda_{\text{next}} = \arg\min_{\lambda_i} ||\lambda_{\text{current}} - \lambda_i||_2^2$$

Pros.

- Very natural extension of the gray-level algorithm
- Yield the same ToS in the gray-level case
- "Look" morphological and few color artefacts

Approach 3. The Graph of Shapes

Idea. Merge the individual ToS into a single structure based on the inclusion that yields a graph.



Cons.

- It is a graph (not a tree) → filtering and reconstruction are more challenging

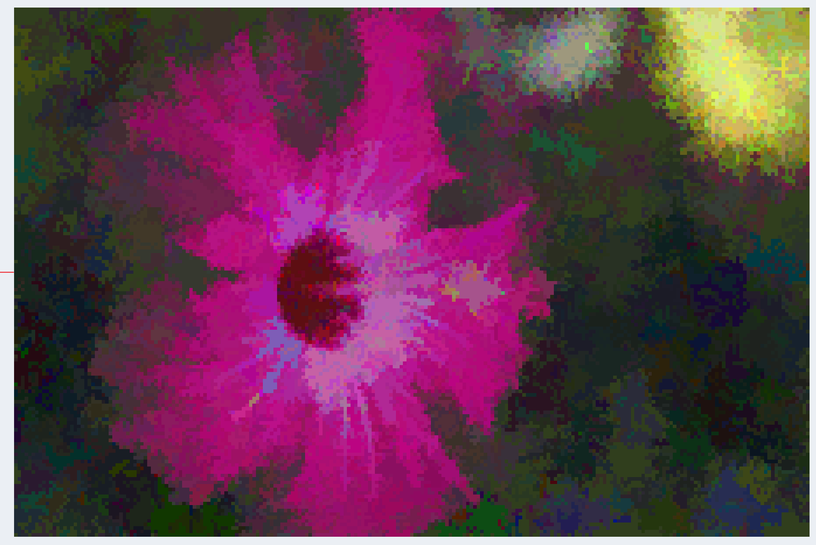
Pros.

- Yield the same ToS in the gray-level case
- Single but rich structure (best denoising score)

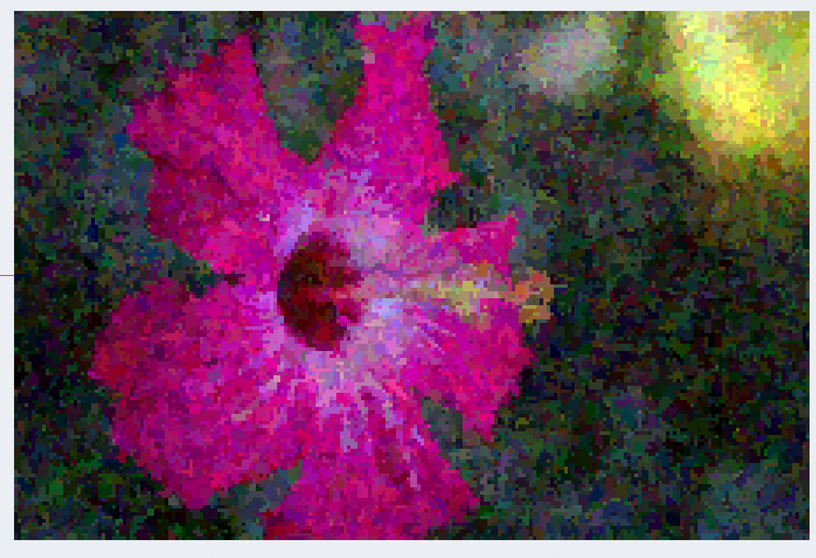
[1] J. Angulo and J. Chanussot. **Color and multivariate images.** In L. Najman and H. Talbot, Eds, *Mathematical Morphology*, chap. 11, pp. 291–321. ISTE & Wiley, 2010.
[2] E. Aptoula and S. Lefèvre. **A comparative study on multivariate mathematical morphology.** *Pattern Recognition*, 40(11):2914–2929, 2007.
[3] T. Géraud *et al.* **A quasi-linear algorithm to compute the tree of shapes of n-D images.** In *Proc. of ISMM*, volume 7883 of *LNCS*, pages 98–110. Springer, 2013.
[4] B. Naegel and N. Passat. **Towards connected filtering based on component-graphs.** In *Proc. of ISMM*, volume 7883 of *LNCS*, pages 353–364. Springer, 2013.

Qualitative evaluation through denoising

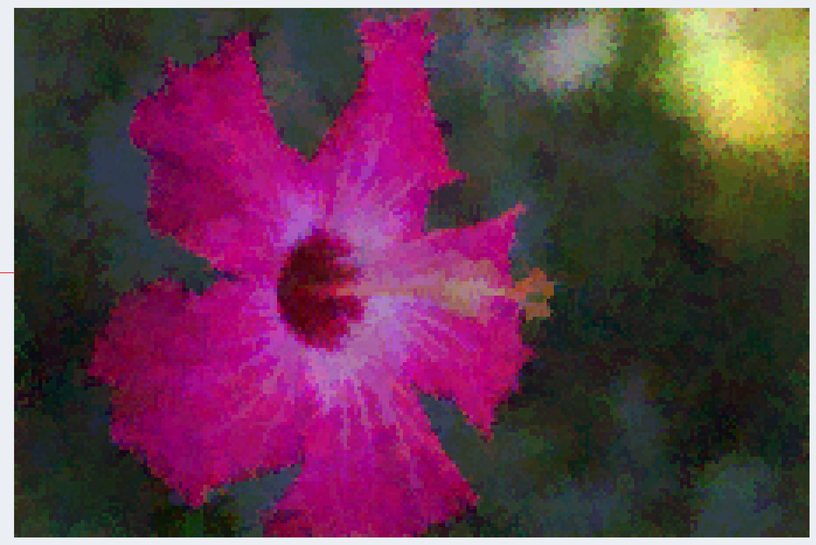
Original image (corrupted). PSNR=36.46



Approach 1. Pre-order based ToS. PSNR=38.23



Approach 2. Distance-based ToS. PSNR=37.88



Approach 3. Graph of Shapes. PSNR=39.98