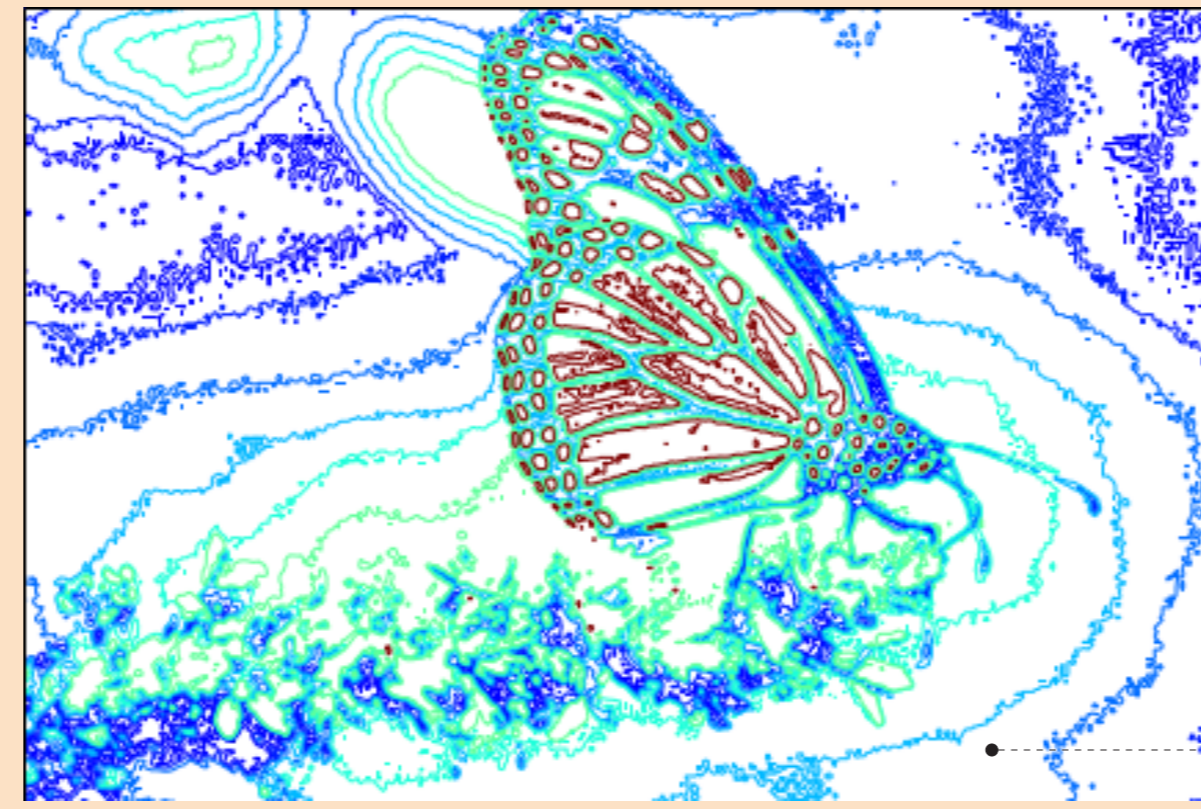
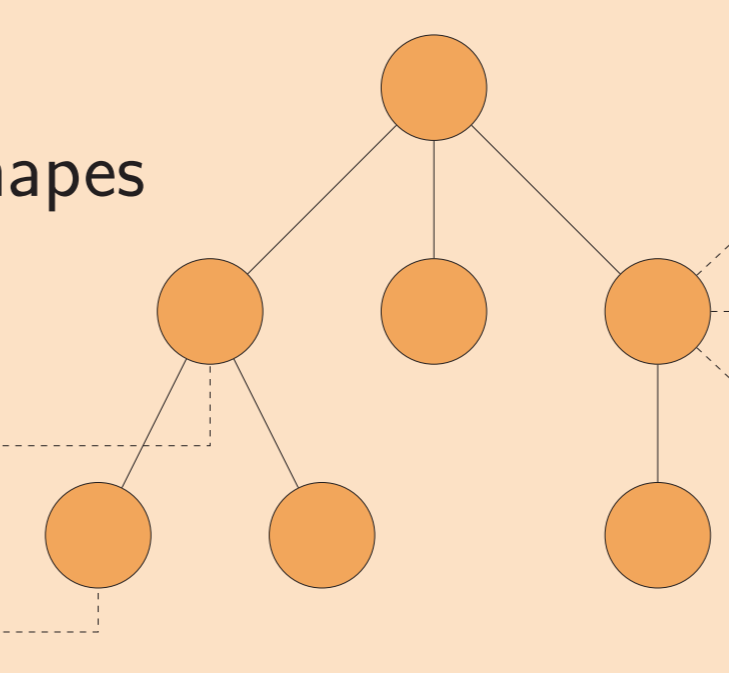




Level lines representation



Tree of Shapes

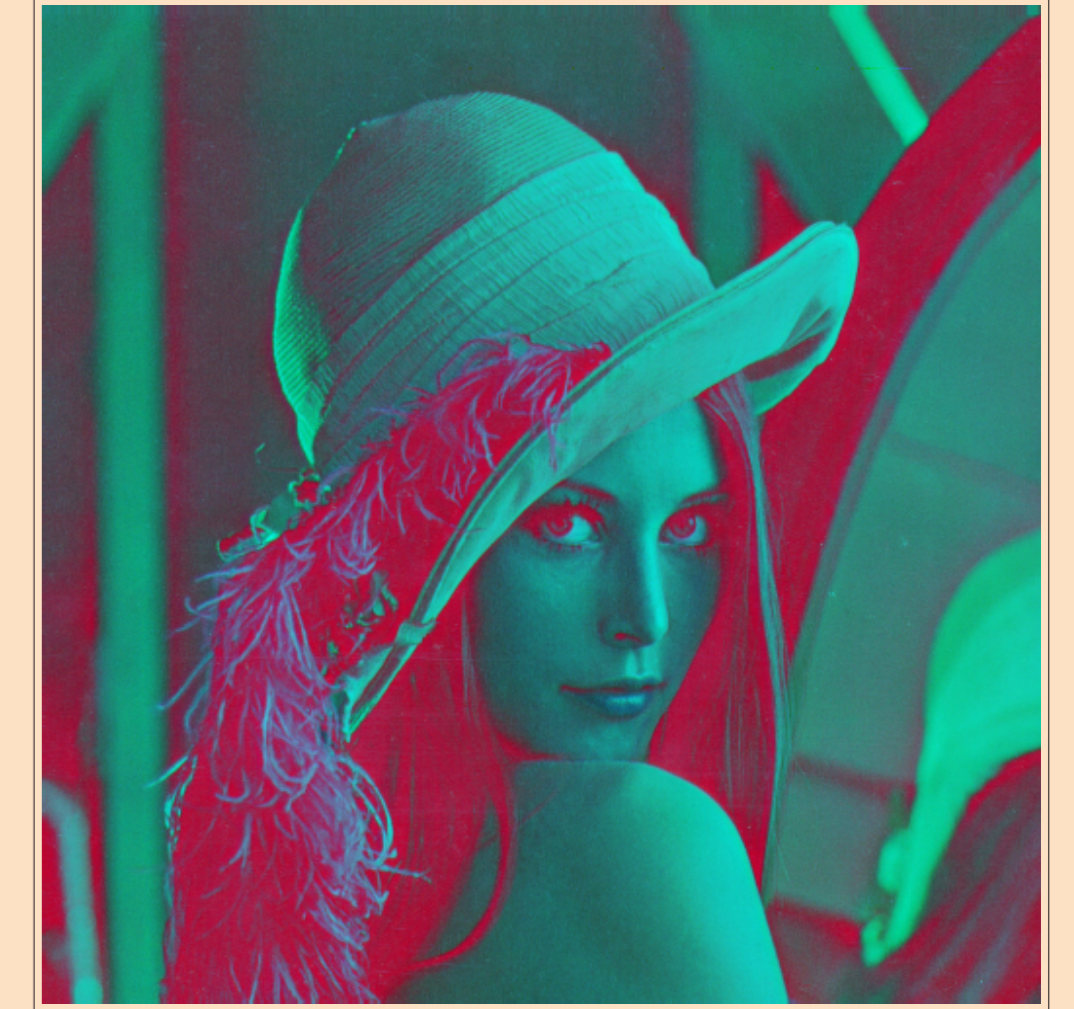
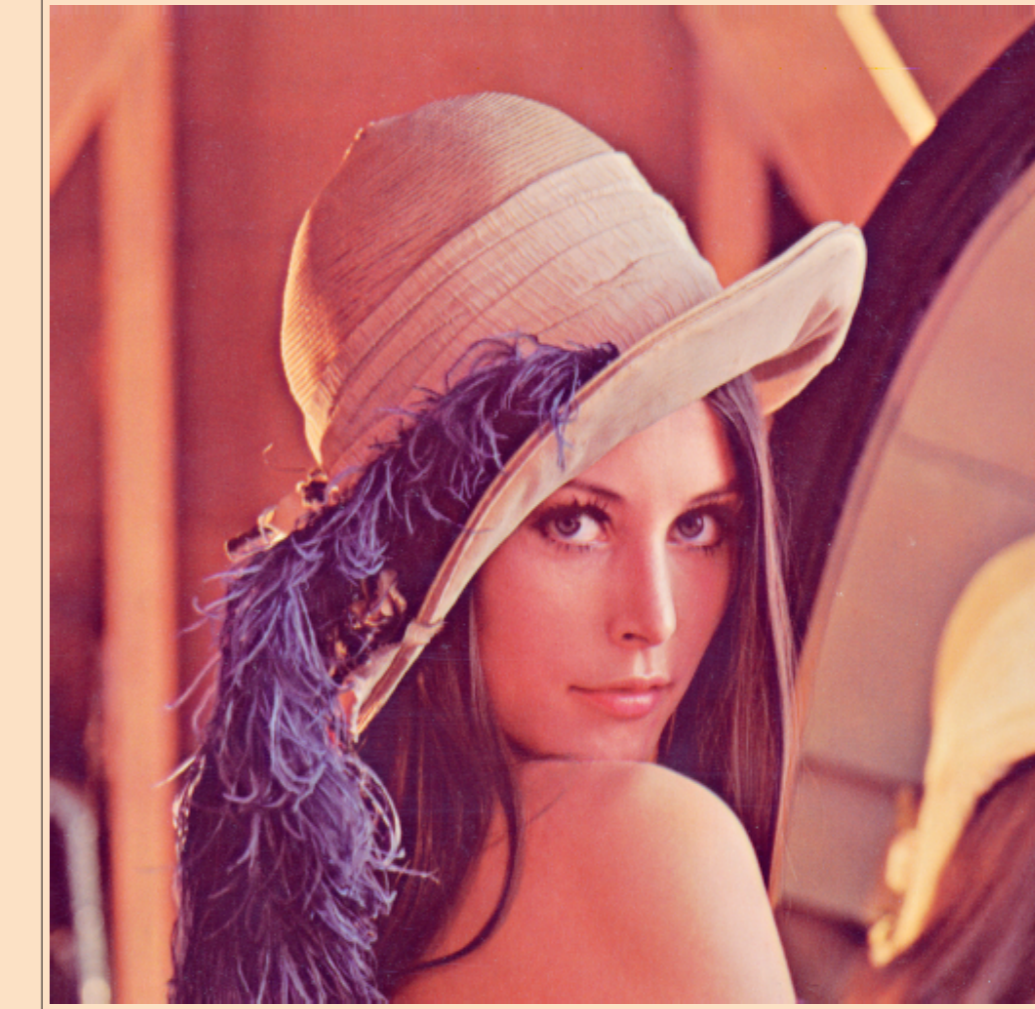


Featuring

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

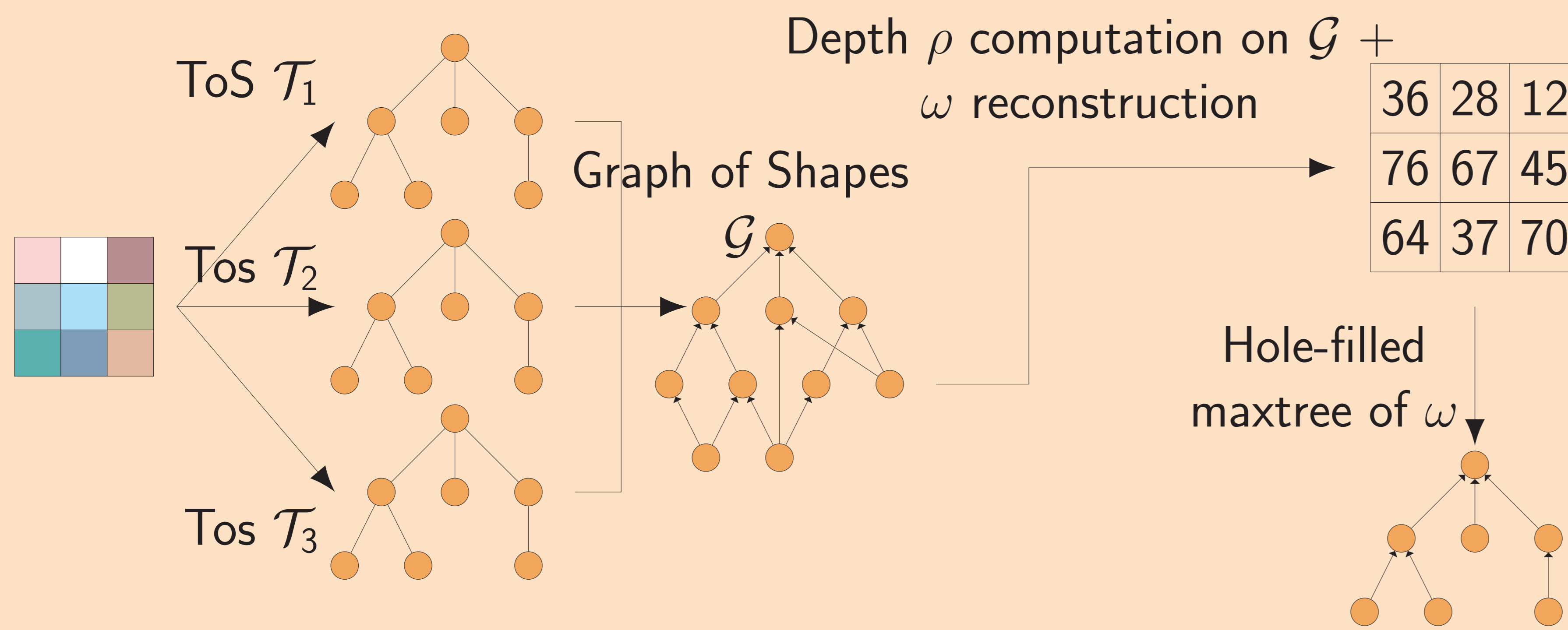
At a Glance

- **Motivation.** The Tree of Shapes (ToS) provides a *high-level representation of the image structure* and has many applications.
- **Objective.** Extend the ToS computation on color images.
- **Problem.** A natural tree **does not** exist for color images, “standard” approaches are not satisfactory.
- **Contribution.** A method that:
 - does **not** rely on any total ordering of colors,
 - is invariant by any marginal change of contrast,
 - is invariant by any marginal inversion of contrast,
 - is equivalent to the “normal” ToS in the gray level case.



The ToS is invariant by contrast and inversion change of contrast → these images have the same tree

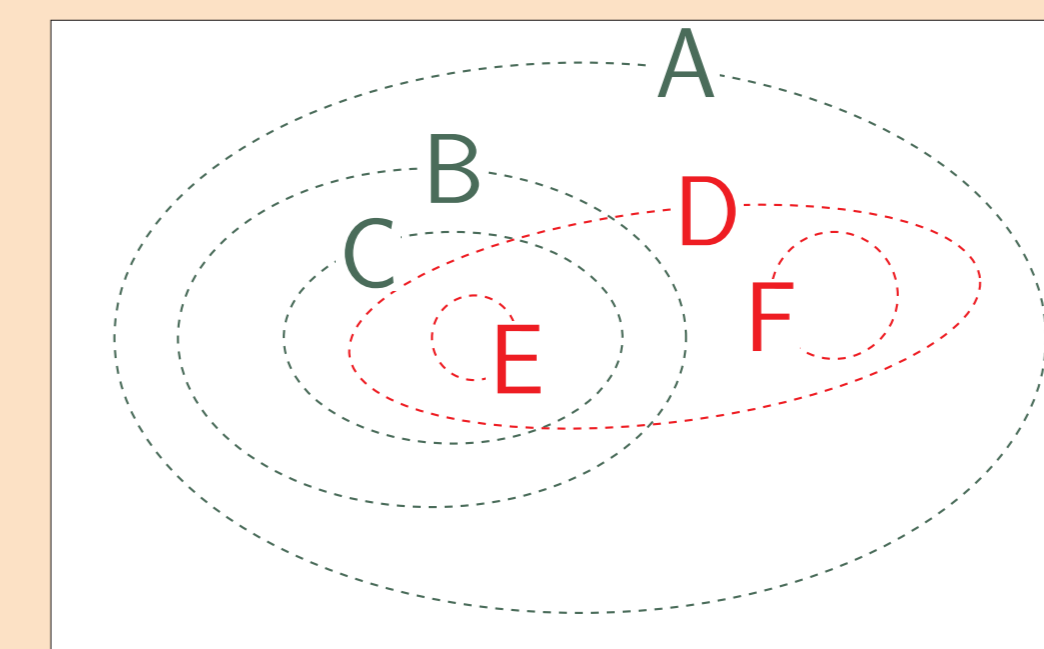
Method Description



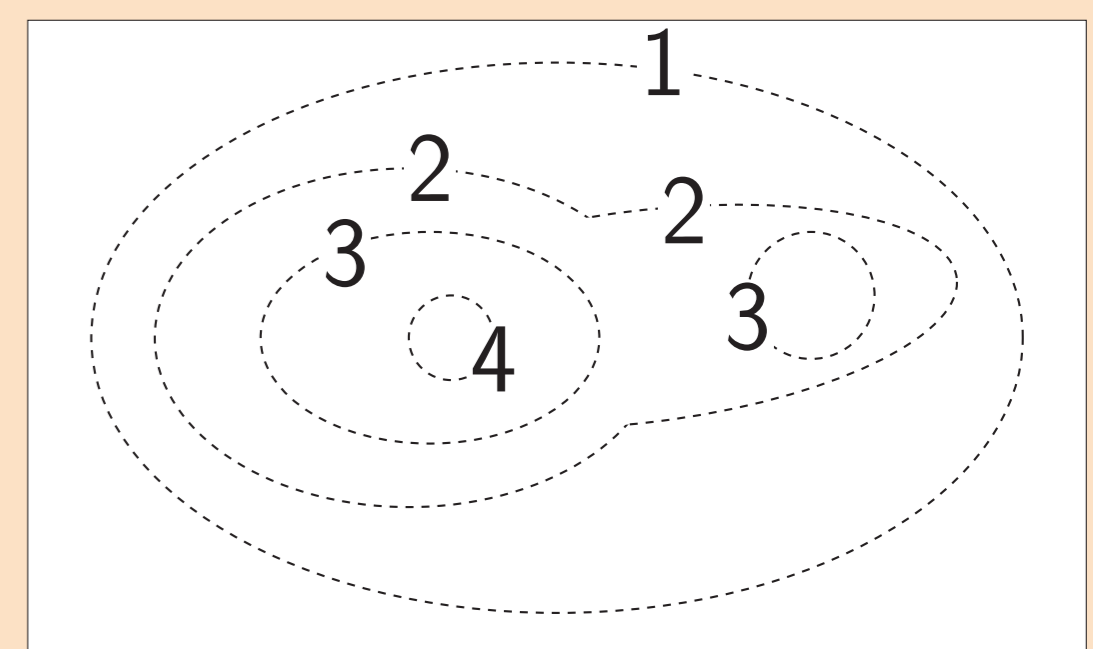
Depth ρ computation on \mathcal{G} + ω reconstruction

36	28	12
76	67	45
64	37	70

Hole-filled maxtree of ω

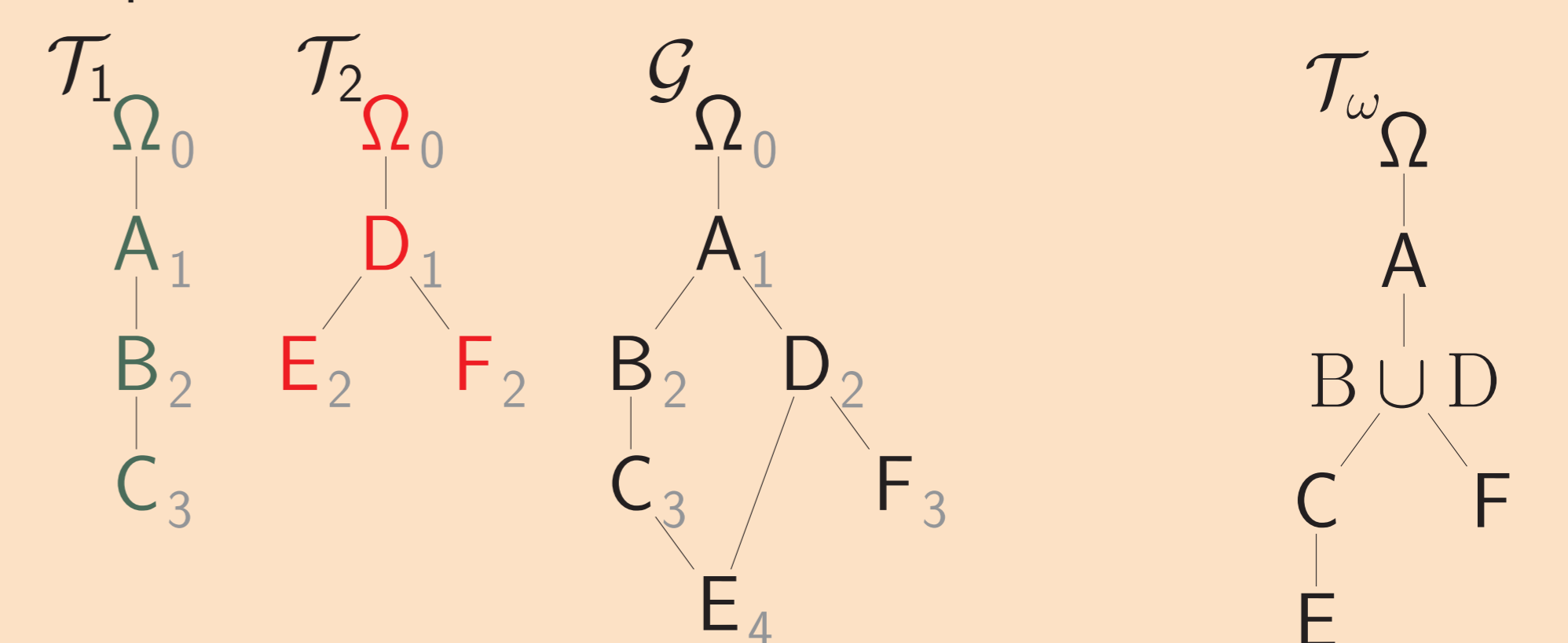


(a) A 2-channel image and its shapes.



(c) ω image built from \mathcal{G}

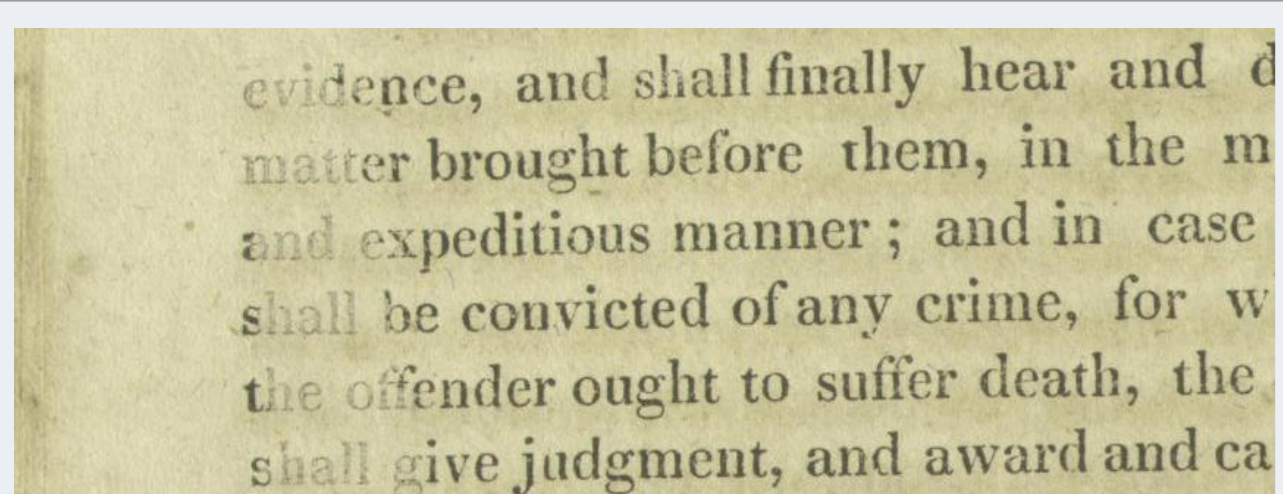
1. Compute the marginal ToS \mathcal{T}_1 , \mathcal{T}_2 and \mathcal{T}_3 .
2. Merge them into a single graph structure \mathcal{G} (the Graph of Shapes (GoS)).
3. Compute the depth ρ of each shape S in \mathcal{G} . The depth is the longest path from the root to that shape.
4. Reconstruct $\omega(x) = \max_{S|x \in S} \rho(S)$
5. Compute the hole-filled maxtree of ω to get the final tree \mathcal{T}_ω .



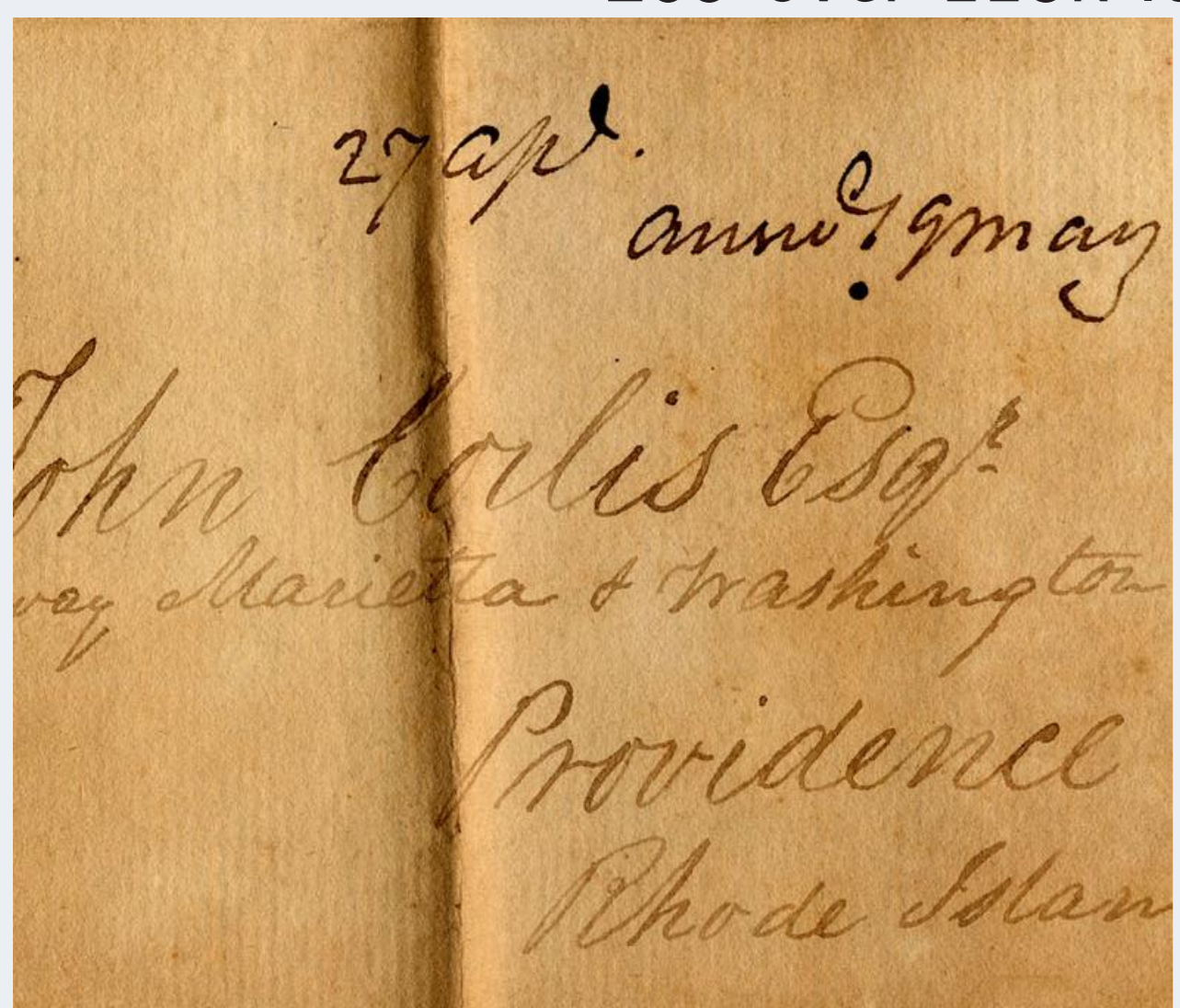
(b) The marginal ToS \mathcal{T}_1 , \mathcal{T}_2 and the GoS (the depth in light gray)

(d) The hole-filled max-tree \mathcal{T}_ω of ω

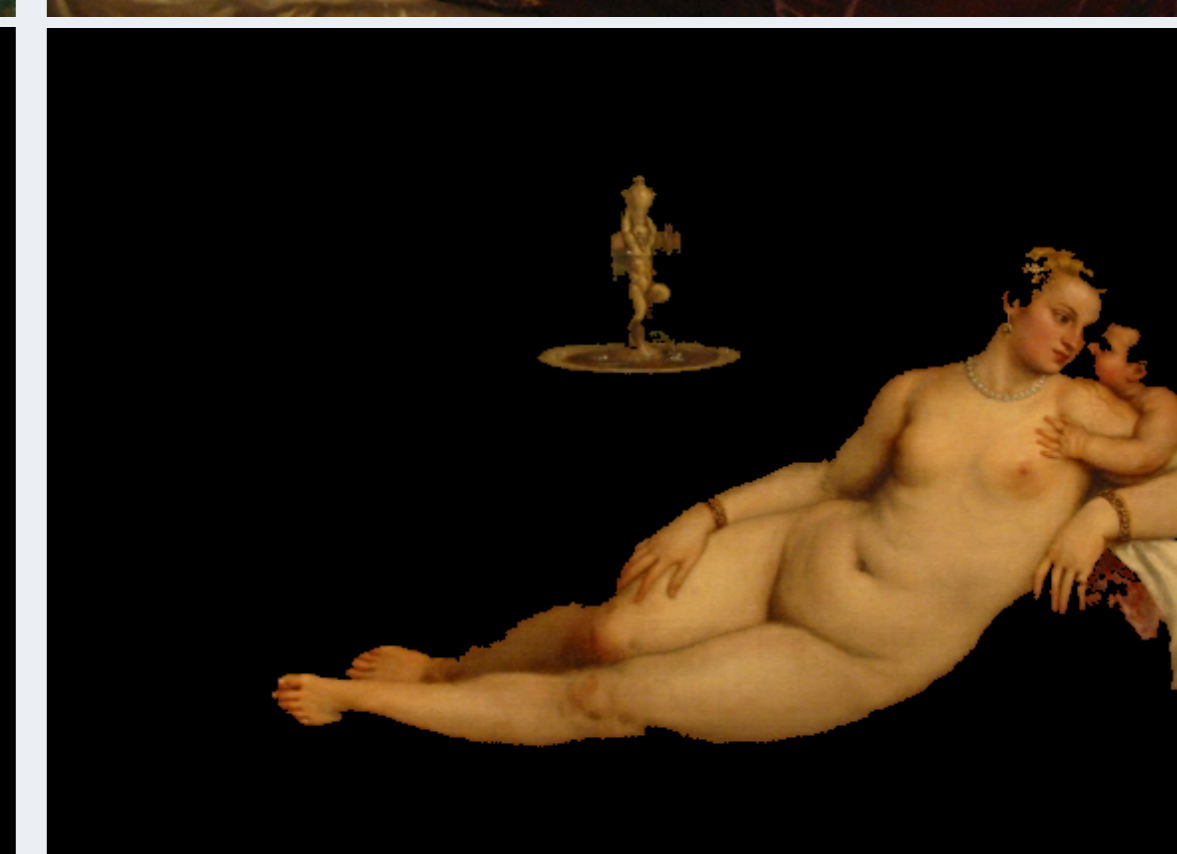
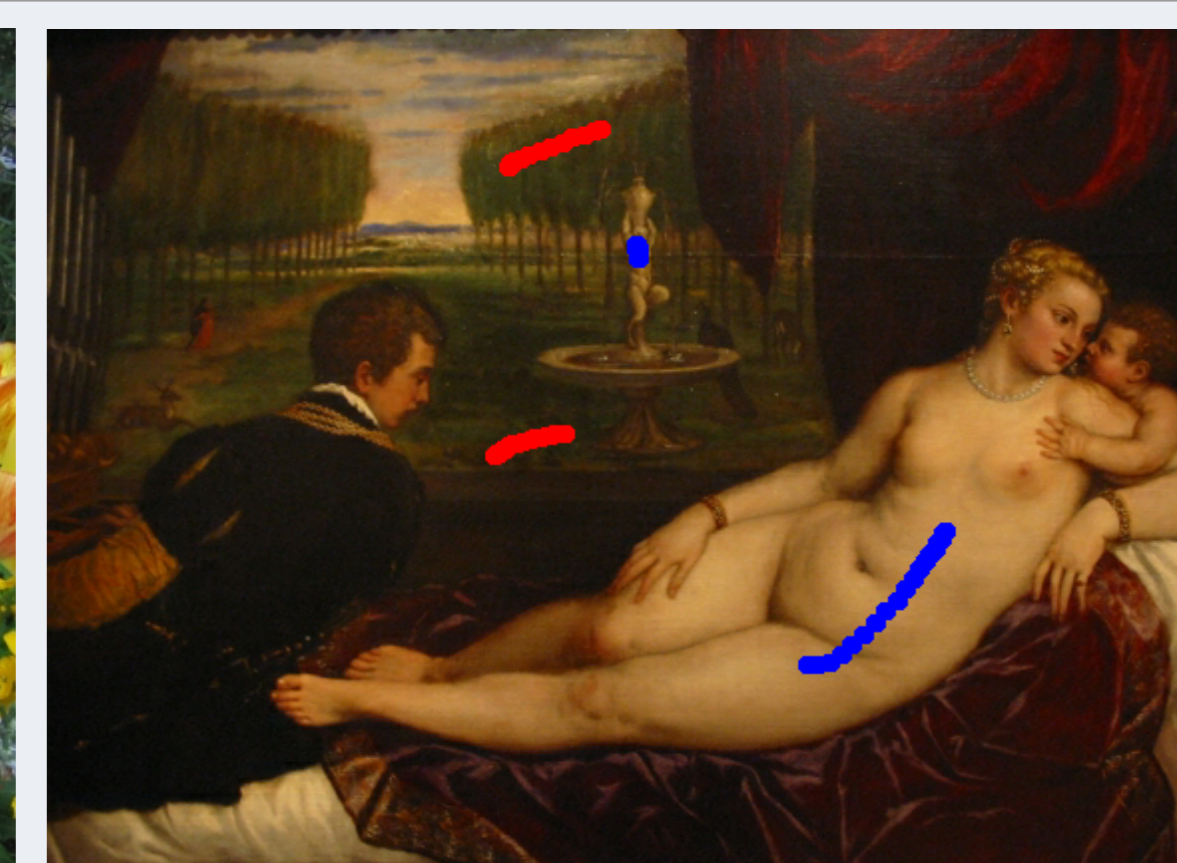
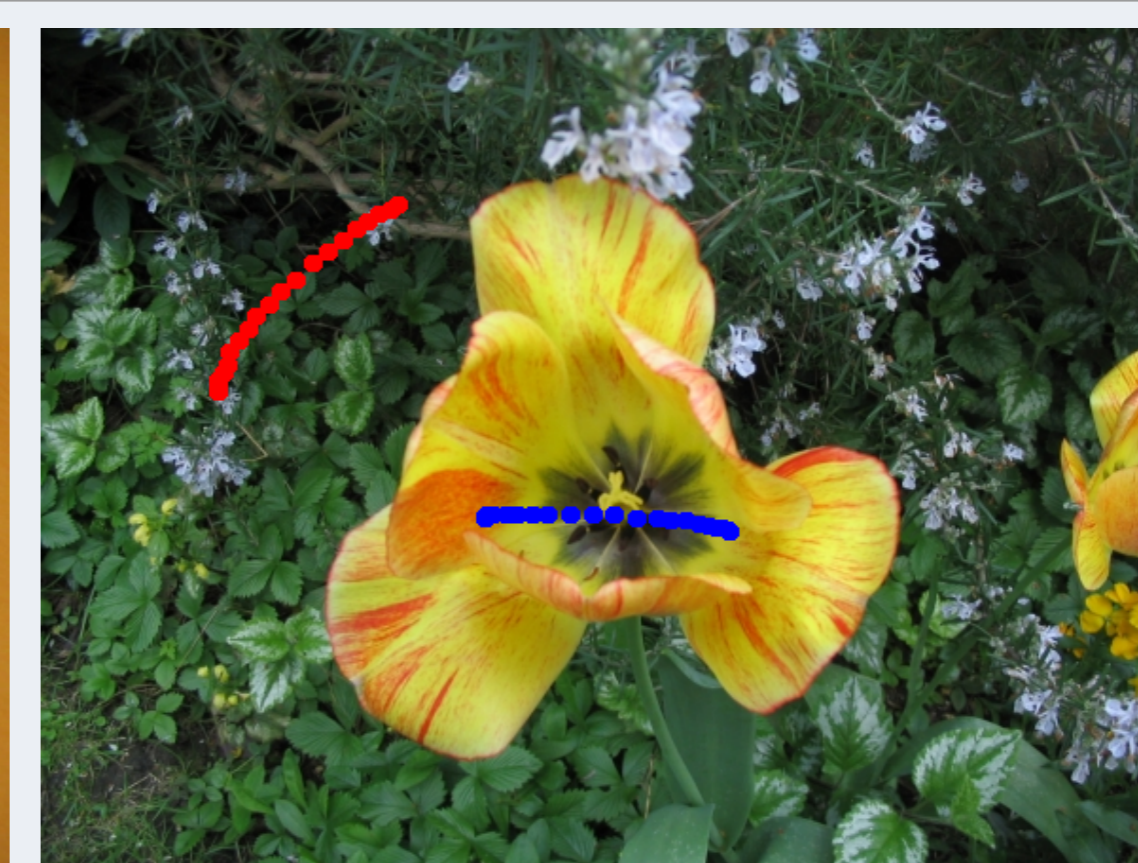
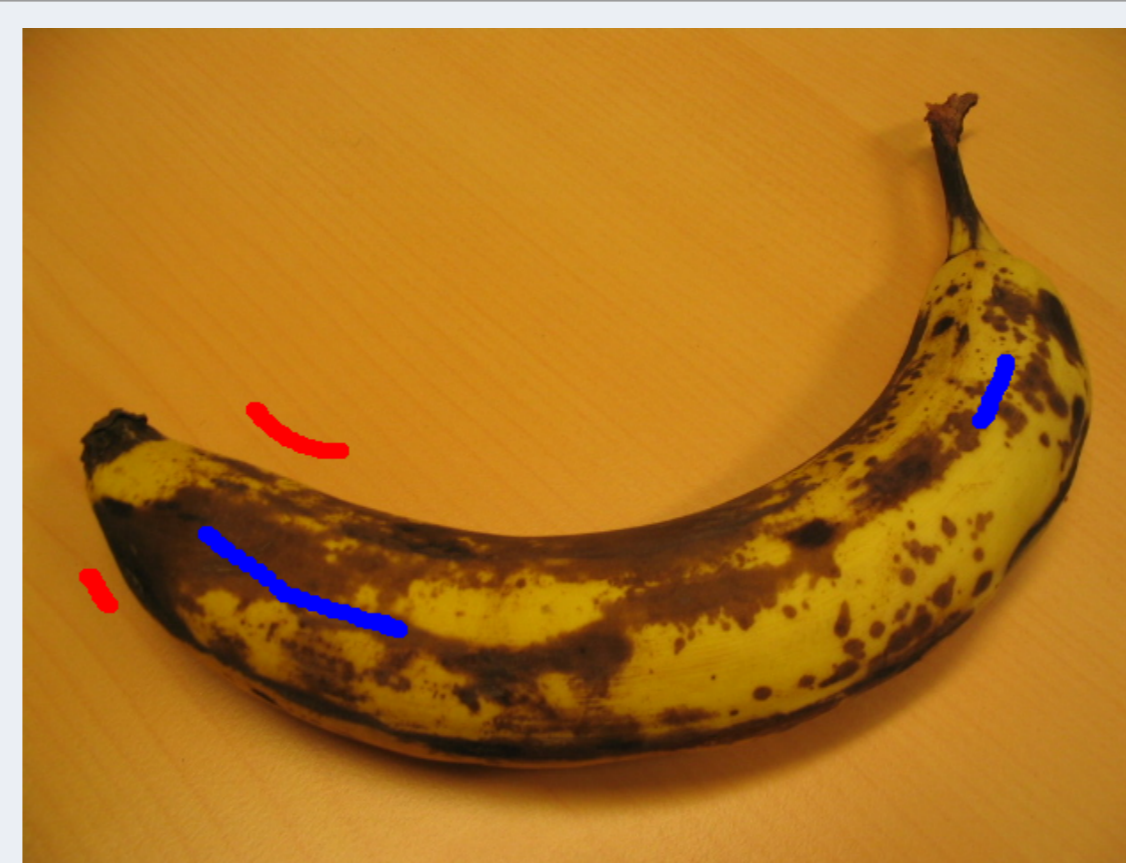
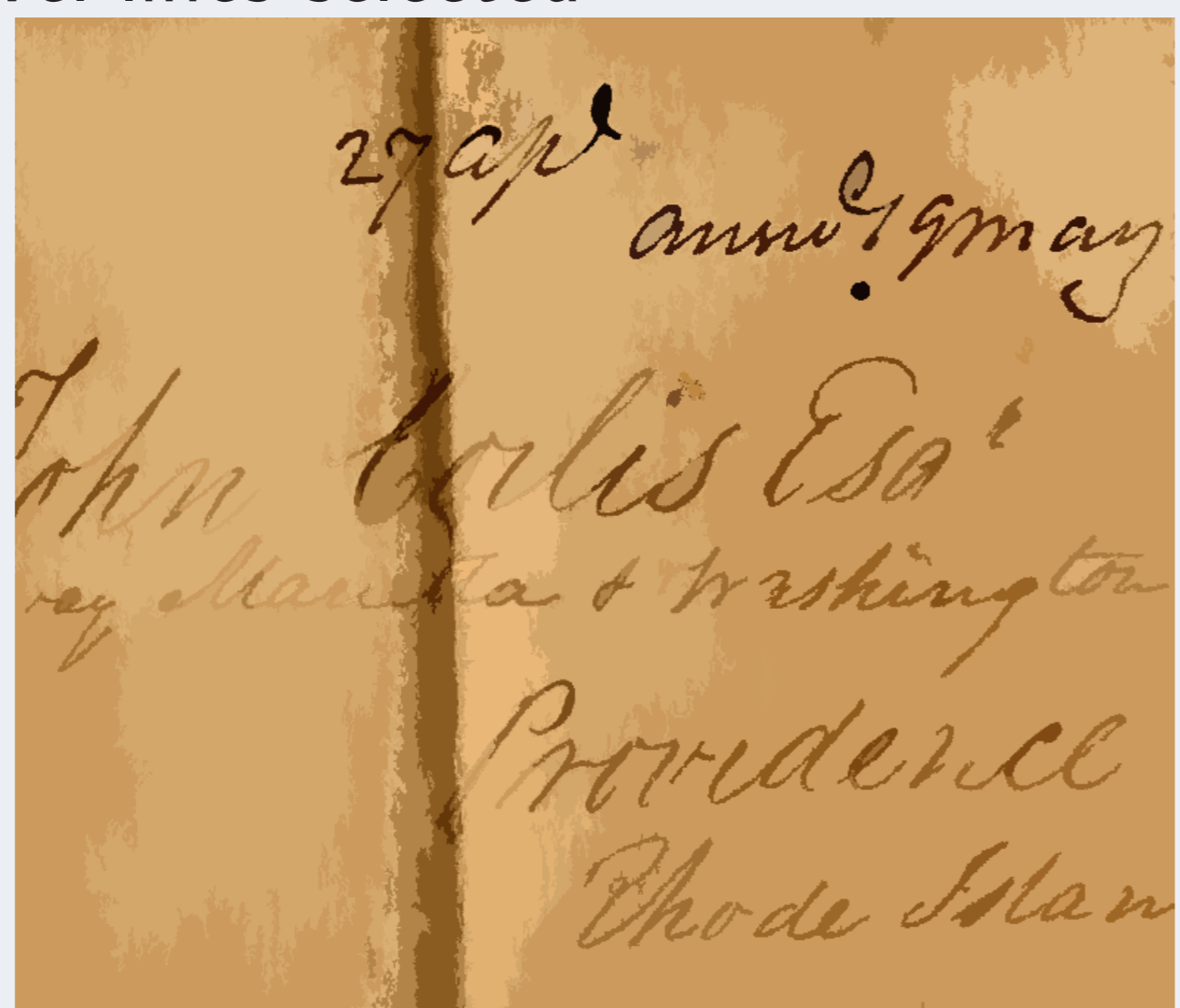
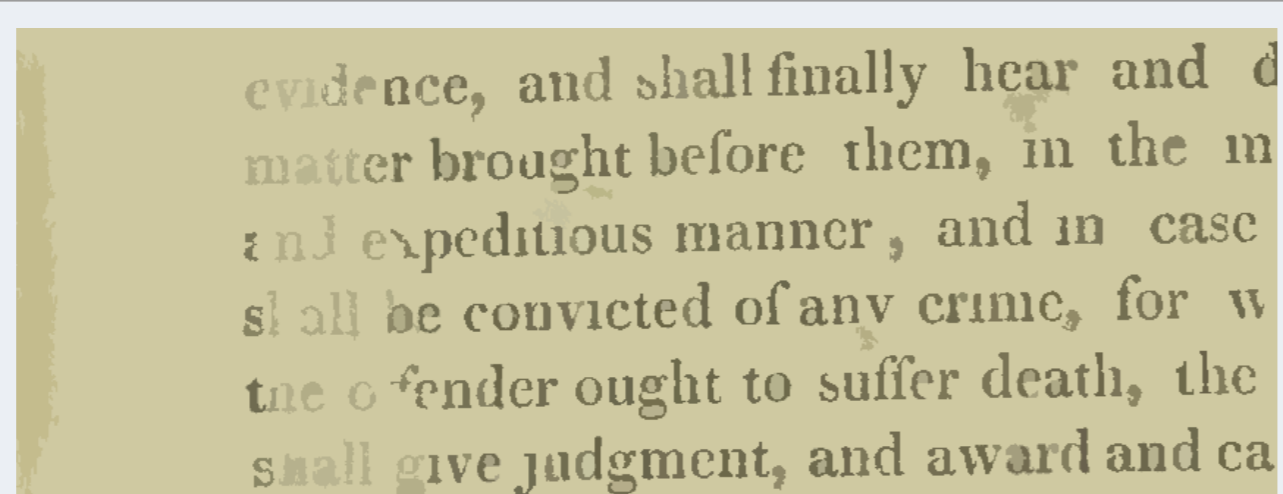
Applications: Image Simplification (left) and Interactive Segmentation (right)



285 over 113k level lines selected



112 over 288k level lines selected



Markers (top row) and segmented images (bottom row)

[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] 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.

[4] E. Carlinet and T. Géraud. **Getting a morphological tree of shapes for multivariate images: Paths, traps and pitfalls.** In *Proc. of IEEE ICIP*, Paris, France, 2014, pp. 615–619.