Image Partitioning into Convex Polygons

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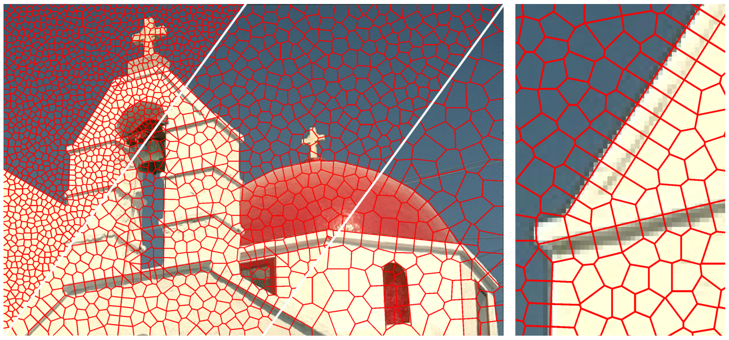


Figure 1: Our algorithm partitions images into regular convex polygons. Three different polygon sizes are displayed. Using floating polygons allow for the preservation of object boundaries at a subpixelic scale (close-up).

1 Introduction

The over-segmentation of images into atomic regions has become a standard and powerful tool in Vision. Traditional superpixel methods, eg [1, 2, 3], that operate at the pixel level, cannot directly capture the geometric information disseminated into the images. This can be particularly penalizing in various applicative scenarios, for instance (i) man-made object/urban modeling (eg analysis of images containing mainly linear structures as buildings), or (ii) segmentation problems when strong spatial guarantees on atomic regions (uniqueness of region connectivity, region convexity) or high performances (time, scalability, storage) are required.

We propose an alternative to the superpixel methods by operating at the level of geometric shapes. The proposed solution consists of partitioning images into connected convex polygons using Voronoi diagrams. Region convexity has many advantages, in particular for (i) simplifying subsequent geometric operations as the computation of region distances, (ii) favoring the region compactness, and (iii) insuring a unique adjacency graph between regions, without ambiguities. In our approach, geometric properties are guaranteed by construction of the Voronoi diagram whereas radiometry is exploited to (i) align edges separating two neighboring polygons with image discontinuities, and (ii) center the polygons in homogeneous areas. Figure 1 illustrates our goal.

2 Algorithm overview

Our algorithm takes an image as input and produces, as output, a partition into polygons defined into the continuous bounded domain supporting the image. A model parameter ε has to be specified to fix the partition scale; concretely ε corresponds to the average radius of a region, assuming the region approaches a rounded shape. The algorithm is composed of three steps illustrated on Fig.2. Line-segments are first extracted from the input image, and consolidated to bring spatial coherence. An initial Voronoi partition that preserves the line-segments and their junctions is then generated by inserting anchors at some specific locations: this part is the key technical contribution of our work. The Voronoi partition is finally homogenized by point process.

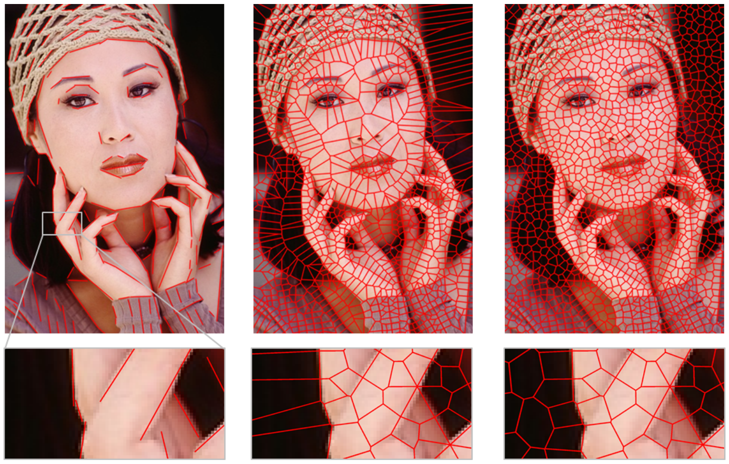
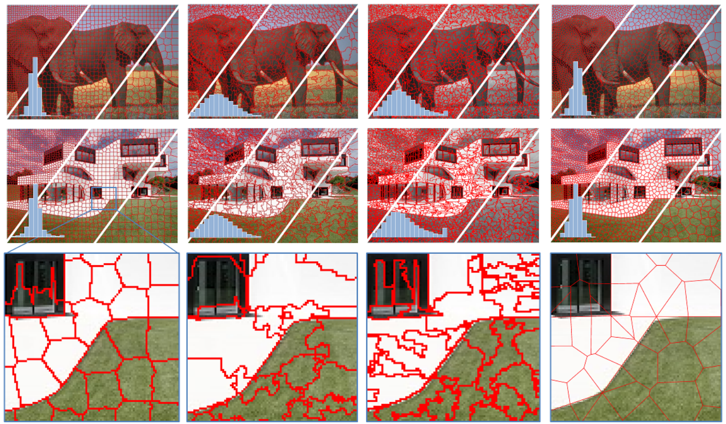


Figure 2: Overview. Left: line-segments are first extracted from the input image, and consolidated to bring spatial coherence. Middle: an initial Voronoi partition that preserves the line-segments and their junctions is then created by inserting anchors at some specific locations. Right: the Voronoi partition is homogenized by point process.



SLIC [1] SEEDS [3] ERS [2] ours

Figure 3: Visual comparison with three state-of-the-art superpixel methods on both natural (top) and man-made scene (bottom) images.

3 Experiments

Although our algorithm produces polygonal regions different from superpixels, we evaluated its potential with comparisons to traditional superpixel methods [1, 2, 3]. Our algorithm outperforms these methods in terms of compactness by a significant margin, and also competes well in terms of undersegmentation error and running time. As manipulating geometric objects, we achieve better scalability, and keep low memory consumption even on very big images. Our result on the boundary recall scores low as the use of line-segments logically penalizes the boundary accuracy. Our method competes well especially for man-made scenes as illustrated on Fig. 3. We also tested the algorithm on large-scale satellite images. Five minutes and 0.8Gb of memory are necessary from a 100Mpixel image. By contrast, the superpixel method ERS requires 39 minutes and 34Gb memory, and the released versions of SLIC and SEEDS do not run on such image size.

[1] R. Achanta, A. Shaji, K. Smith, A. Lucchi, P. Fua, and S. Susstrunk. Slic superpixels compared to state-of-the-art superpixel methods. *PAMI*, 34 (11), 2012.

[2] M.-Y. Liu, O. Tuzel, S. Ramalingam, and R. Chellappa. Entropy rate superpixel segmentation. In *CVPR*, 2011.

[3] M. Van den Bergh, X. Boix, G. Roig, B. De Capitani, and L. Van Gool. SEEDS: Superpixels extracted via energy-driven sampling. In *ECCV*, 2012.

This is an extended abstract. The full paper is available at the Computer Vision Foundation webpage.