An Order-Independent Sequential Thinning Algorithm

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Skeletons are region-based shape descriptors which summarize the general form of objects/shapes. An illustrative definition of the skeleton is given using the prairie-fire analogy: the object boundary is set on fire and the skeleton is formed by the loci where the fire fronts meet and extinguish each other [1]. Thinning is a frequently used method for making an approximation to the skeleton in a topology–preserving way [2]. It is based on a digital simulation of the fire front propagation: the border points of a binary object that satisfy certain topological and geometric constraints are deleted in iteration steps. The entire process is then repeated until only the "skeleton" is left. Most of the existing thinning algorithms are parallel as the fire front propagation is by nature parallel, but numerous sequential ones were also proposed [3].

A simple point is an object point whose deletion does not alter the topology of the picture [2]. Sequential thinning algorithms use operators that delete some simple points which are not end points, since preserving end–points provides important geometrical information relative to the shape of the objects. Unfortunately, the existing algorithms produces various results for different (say forward and backward) scans of the points.

We propose a new sequential thinning algorithm based on the notion of critical pairs of points. Let p and q be two 4-neighboring object points. We define the $\{p, q\}$ set as critical pair if the following conditions are satisfied:

- $C(p) = C(q) = 1$,
- $3 \leq B(p) \leq 6$ and $3 \leq B(q) \leq 6$,
- $C(p, q) = 2$,

where $C(p)$ is the number of black components in the neighborhood of p , $B(p)$ denotes the number of black points in the 8-neighborhood of p , and $C(p, q)$ is the number of black components in the 8-neighborhood of $\{p, q\}$.

Using a special classification of critical pairs, some statements can be made about neighbouring object points. With the help of these rules, we define the pixel removal conditions of our algorithm. Furthermore, we use an additional matrix to store the previously deleted points in the current iteration. This information also helps us to decide if a point is erasable or not.

It is proven that our algorithm is topology preserving for $(8, 4)$ binary pictures and order independent. Results on two test pictures produced by the proposed algorithm are presented in Fig. 1.

References

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[2] T.Y. Kong, A. Rosenfeld, Digital topology: Introduction and survey, *Computer Vision, Graphics, and Image Processing* 48, 1989, 357–393.

[3] L. Lam, S.-W. Lee, C.Y. Suen, Thinning methodologies – A comprehensive survey, IEEE Trans. *Pattern Analysis and MachineIntelligence* 14, 1992, 869–885.

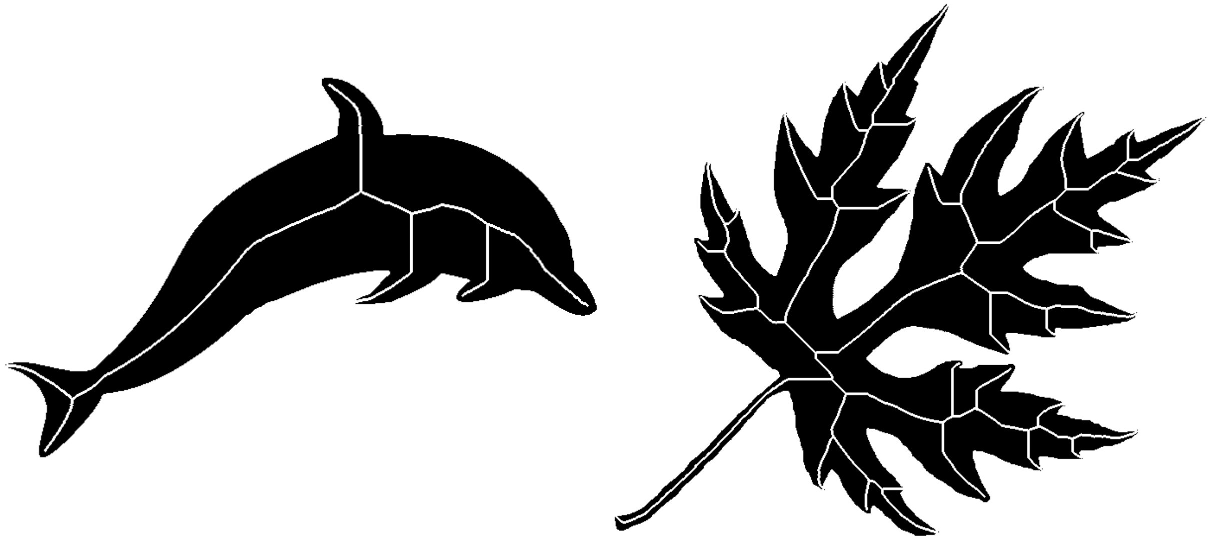

Figure 1: A 612×398 image of a dolphin (left) and a 700×633 image of a leaf (right). The "skeletons" produced by our algorithm are superimposed on the original images.