Multiscale Analysis of Discrete Contours for Unsupervised Noise Detection

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Abstract

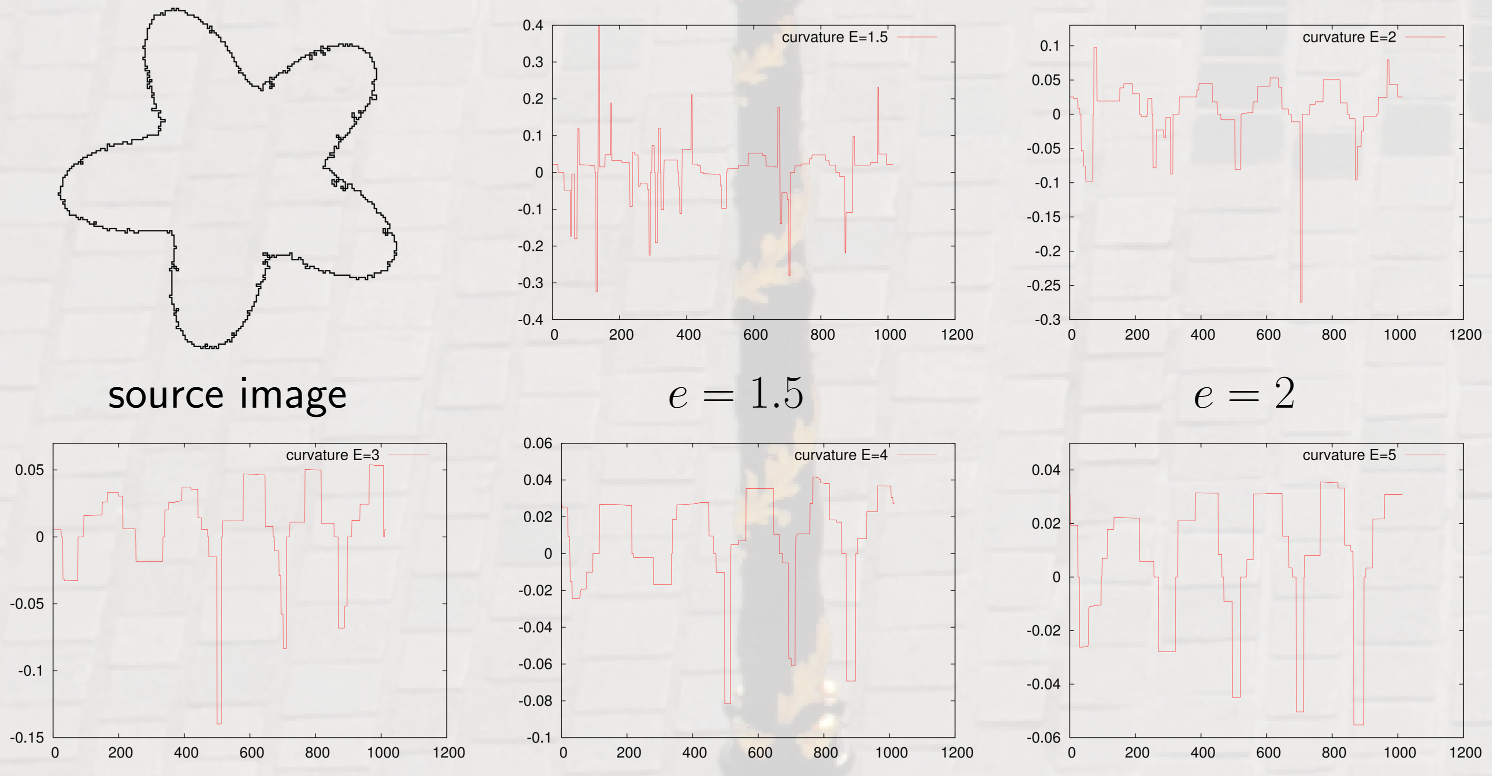
We propose an original strategy to detect locally both the amount of noise and the meaningful scales of each point of a digital contour. Based on the asymptotic properties of maximal segments, it also detects curved and flat parts of the contour. From a given maximal observation scale, the proposed approach does not require any parameter tuning and is easy to implement [2].

Keyword: Noise and meaningful scale detection, maximal segments.

1 Introduction

Motivation:

- Output quality/accuracy depends on the choice of the parameter.
- Relevance of a global parameter.
- Example: Geometric estimators (curvature, tangent), etc..



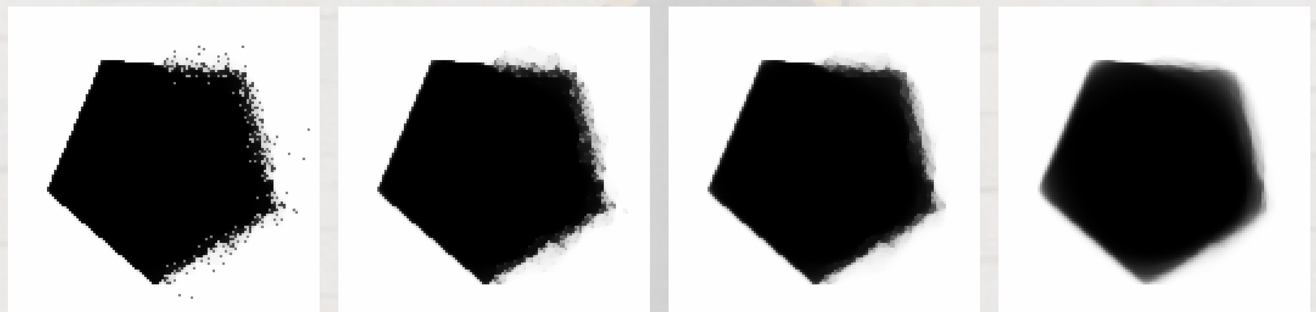
source image, $e = 1.5$, $e = 2$, $e = 3$, $e = 4$, $e = 5$

Few works are adapted for estimating and remove noise on binary images

- Morphological openning:

input, Open (r=2), Open (r=4), Open (r=10)

- Noise removal using Rudin *et al.*algorithm [4]:



$\lambda = 2$, $\lambda = 1$, $\lambda = 0.5$, $\lambda = 0.1$

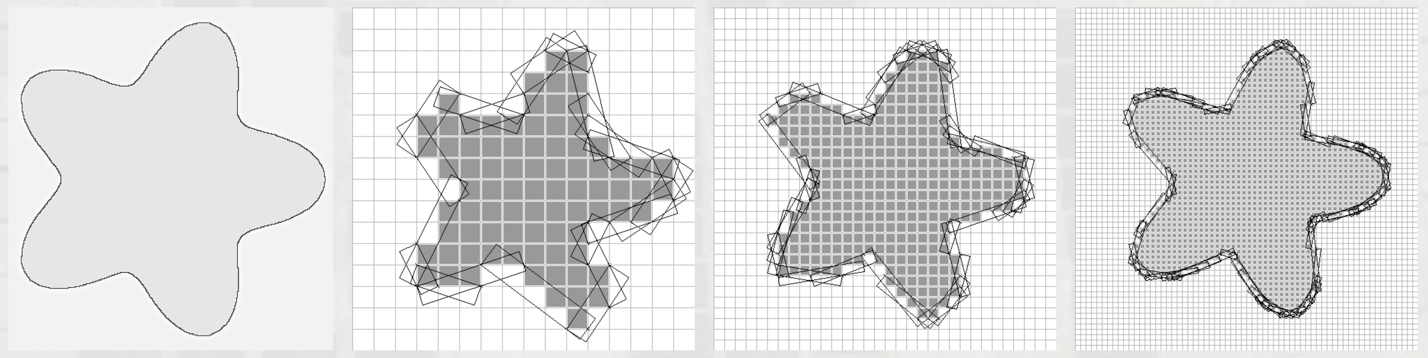
2 Scale properties of maximal segments

Main idea: Local shape analysis of digital contours

1. Exploit asymptotic properties of perfect shape digitizations.
2. Estimate them from a multiresolution decomposition of the input shape.
3. Compare them to determine a local meaningful scale.

2.1 Asymptotic properties of shape digitizations

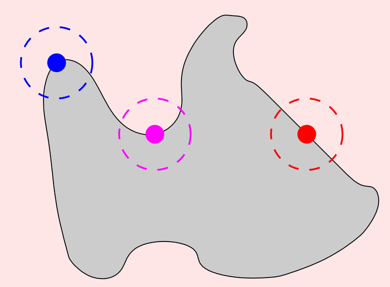
- X some simply connected compact shape of $\mathbb{R}^2$
- $\mathrm{Dig}_h(X) =$ Gauss digitization of X with step h
- black boxes are the maximal segments of its boundary.
- they grow longer (in number of steps) as h gets finer.



X, $\mathrm{Dig}_2(X)$, $\mathrm{Dig}_1(X)$, $\mathrm{Dig}_{0,5}(X)$

Theorem [3]: asymptotic behavior of the length of maximal segments

- X simply connected shape in R^2 with piecewise C^3 boundary ∂X,
- U an open connected neighborhood of $p \in \partial X$,
- (L_j^h) the digital lengths of the maximal segments of $\mathrm{Dig}_h(X)$ which cover p,



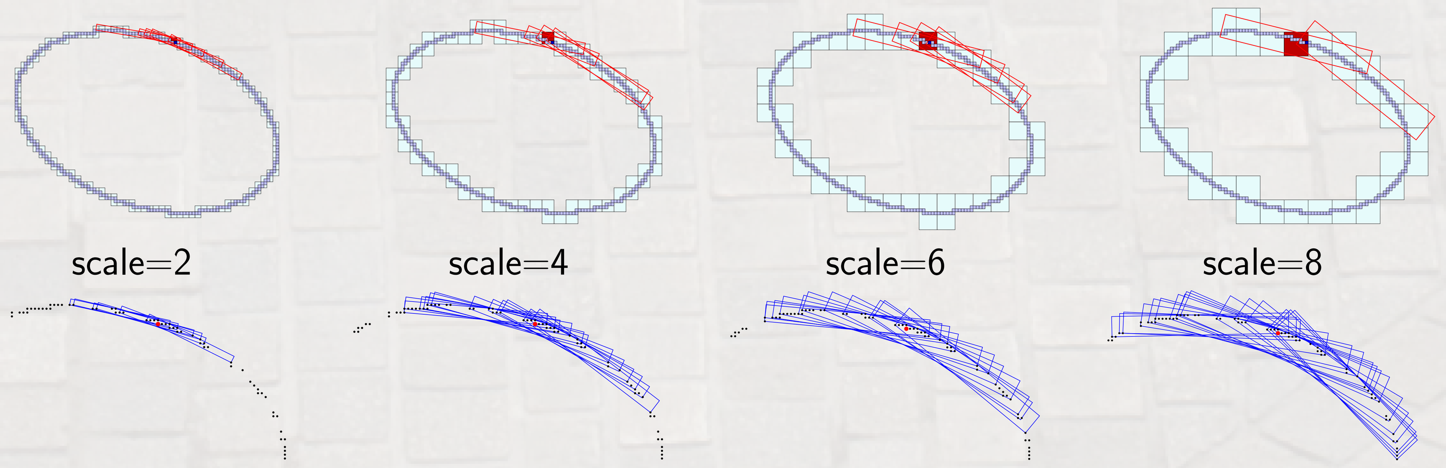
$\partial X \cap U$ strictly convex or concave, then $\Omega(1/h^{1/3}) \leq L_j^h \leq O(1/h^{1/2})$

$\partial X \cap U$ has null curvature, then $\Omega(1/h) \leq L_j^h \leq O(1/h)$

2.2 Asymptotic estimation with multiresolution

Main idea: : reverse asymptote with multiresolution

- Coarser and coarser sampling of the contour.
- Measure digital lengths of maximal segments.
- Should also follow approximately asymptotic behavior.

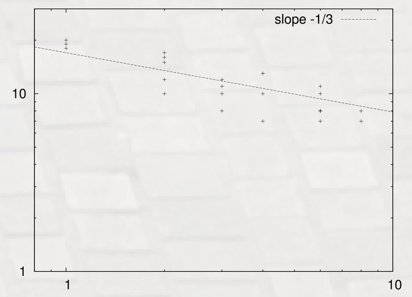


scale=2, scale=4, scale=6, scale=8

width=$\sqrt{2}$, width=$2\sqrt{2}$, width=$6\sqrt{2}$, width= $8\sqrt{2}$

Blurred segment [1]

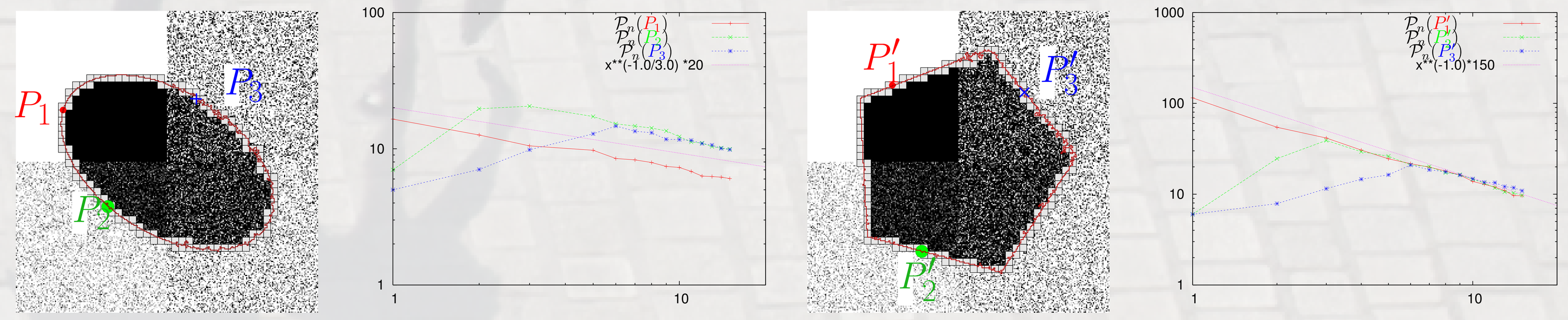
local shape geometry	length($\frac{1}{h}$)	slope log-scale
convex, concave	$\Omega((\frac{1}{h})^{\frac{1}{3}}) \leq \cdot \leq O((\frac{1}{h})^{\frac{1}{2}})$	$-\frac{1}{2} \leq \cdot \leq -\frac{1}{3}$
flat	$\Theta(\frac{1}{h})$	≈ -1
noise otherwise		



2.3 Meaningful scale

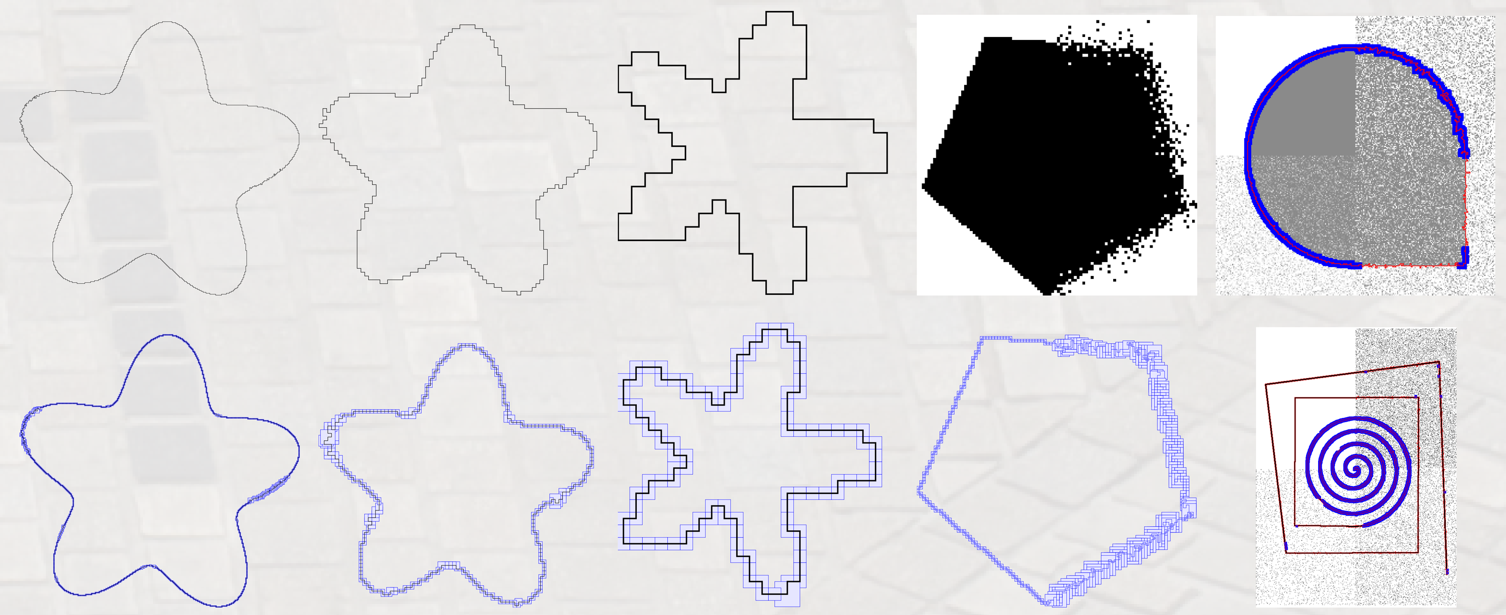
A meaningful scale of a multi-scale profile $(X_i, Y_i)_{1 \leq i \leq n}$ is the pair (i_1, i_2) $1 \leq i_1 \leq i_2 \leq n$ such that for all i, $i_1 \leq i < i_2$: $\frac{Y_{i+1} - Y_i}{X_{i+1} - X_i} \leq t_m$

while not true for $i_1 - 1$ and i_2 and $t_m =$ noise threshold to discriminate curved from noisy areas.
⇒ If (i_1, i_2) is the first meaningful scale at point P, the noise level at point P is $i_1 - 1$.



3 Experiments

- Application on discrete contours



- Application with Blurred Segments on polygonal contour and extraction of meaningful contours:

Meaningful scales on polygon, Set of iso contours, Meaningful contours

References

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