Adaptive Pseudo-Dilation for Gestalt Edge Grouping and Contour Detection

Giuseppe Papari and Nicolai Petkov

Institute of Mathematics and Computing Science, University of Groningen, P.O.Box 407, 9700 AK Groningen, The Netherlands
G.Papari@rug.nl, petkov@rug.nl,

Abstract

We propose a contour detector which performs global analysis of the input image, in order to discriminate between texture edges and object contours. We introduce a new morphological operator, called adaptive pseudo-dilation (APD), which uses context dependent structuring elements in order to identify long curvilinear structures in the edge map. We show that grouping edge pixels as the connected components of the output of APD results in a good agreement with the gestalt law of good continuation (GLGC). The novelty of this operator is that dilation is limited to the Voronoi cell of each edge pixel. An efficient implementation of APD is provided. The grouping algorithm is then embedded in a multi-threshold contour detector. At each threshold level, small groups of edges are removed, and contours are completed by means of a generalized reconstruction from markers. The use of different thresholds makes the algorithm less sensitive to the values of the input parameters. Both qualitative and quantitative comparison with existing approaches prove the superiority of the proposed contour detector in terms of larger amount of suppressed texture and more effective detection of low-contrast contours.

Adapdive pseudo-dilation (APD)

APD is a new morphological operator

Input

- A point set $b = \{\mathbf{r}_1, \dots, \mathbf{r}_N\}$
- A set of **local structuring elements** (LSE) $\mathcal{R} = \{R_1, \dots, R_N\}$
  - » Each LSE is a subset of $\mathbb{R}^2$

Output

$$\operatorname{apd}(b) \triangleq \bigcup_k R_k \cap V(\mathbf{r}_k) \qquad V(\mathbf{r}_k) = \text{Voronoi cell of point } \mathbf{r}_k$$

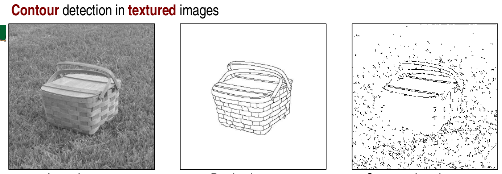
APD is the union of all intersections of each LSE R_k with the Voronoi cell $V(\mathbf{r}_k)$ of the corresponding point

➢ Efficient implementation of APD (see [1] for details)

Introduction

Task

Contour detection in **textured** images



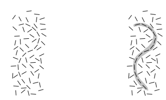
Input image — Desired output — Canny edge detector

Problems

- **Local** luminance changes may be stronger on texture than on contour points
- **Global** analysis is needed

Approach

- Grouping edges (Good continuation)
  - » Adaptive Pseudo-dilation
- Multithreshold



Edges — Good continuation grouping

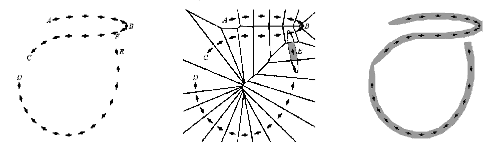
Gestalt edge grouping by means of APD

Input

- An edge point set $b = \{\mathbf{r}_1, \dots, \mathbf{r}_N\}$ with local orientations $\theta_1, \dots, \theta_N$

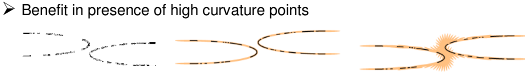
Algorithm

- Computation of $\mathcal{D}_b = \operatorname{apd}(b)$
  - » Each LSE R_k is an **ellipse** oriented along the **local edge direction** θ_k
- Connected components of $\mathcal{D}_b \Leftrightarrow$ groups



Input edge set — Voronoi diagram — Output of APD

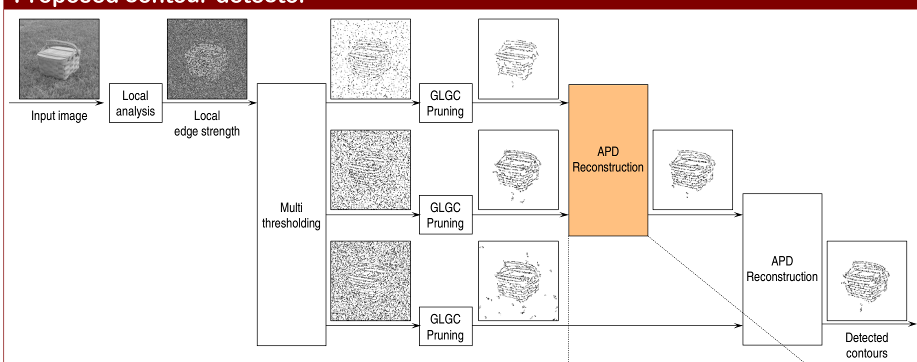
➢ Benefit in presence of high curvature points



Incomplete contours — APD — APD without Voronoi intersection

➢ Automatic adaptive selection for the LSE size (see [1] for details)

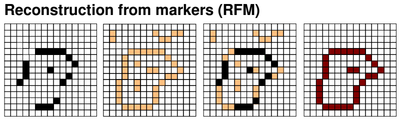
Proposed contour detector



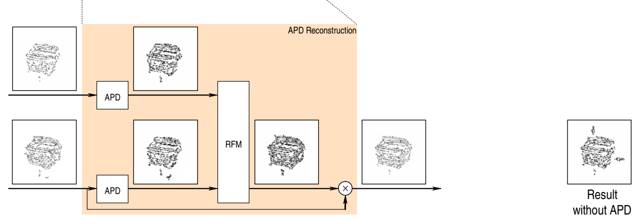
Algorithm

1. Local edge strength
2. Multi-thresholding
3. At each threshold level:
   - » GLGC Pruning
   - » APD reconstruction

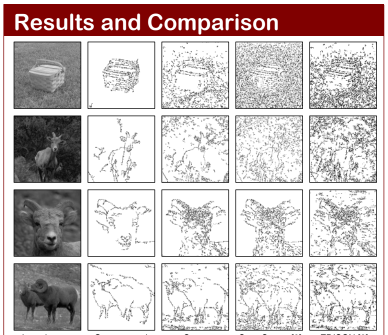
Reconstruction from markers (RFM)



Incomplete contours (markers) — Overcomplete contours — Superposition — Reconstructed image



Results and Comparison



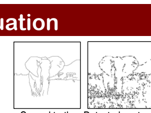
Input image — Our approach — Canny — Surr. Suppr. [2] — EDISON [3]

➢ Results for more than 300 images available at
http://www.cs.rug.nl/~imaging/APD

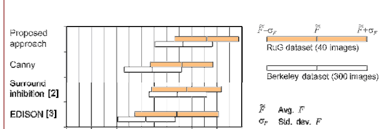
Performance Evaluation

- Performance indicators

$$\begin{cases} R = \dfrac{\operatorname{card}\{DC \cap GT\}}{\operatorname{card}\{GT\}} \\ P = \dfrac{\operatorname{card}\{DC \cap GT\}}{\operatorname{card}\{DC\}} \\ F = \dfrac{2PR}{P+R} \end{cases}$$



Ground truth (GT) — Detected contours (DC)



Statistics of F for two image datasets

Summary and Conclusions

- Edge grouping with APD
  - » Agreement with GLGC
  - » Efficient computation
  - » Adaptive size of the LSE
- Multithreshold contour detection
  - » Little dependence on input parameters
  - » Highest performances in terms of
    1. Texture suppression
    2. Preservation of low'contrast contours

References

[1] G. Papari, N. Petkov, "Adaptive Pseudo-Dilation for Gestalt Edge Grouping and Contour Detection", to appear on *IEEE Transactions on Image Processing*

[2] C. Grigorescu, N. Petkov, M. A. Westenberg "Contour and boundary detection improved by surround suppression of texture edges", *Image and Vision Computing*, **22**(8), 2004, 609-622.

[3] P. Meer, B. Georgescu, "Edge detection with embedded confidence", *IEEE Transactions on Pattern Analysis and Machine Intelligence* **23**(12) (2001) 1351–1365.