Automatic contour extraction of neurons in presence of overlap

Jorge J. G. Leandro*, Roberto M. Cesar Jr*, Luciano da Fontoura Costa†
* IME - USP , Email: {jleandro,cesar}@vision.ime.usp.br
† IFSC - USP, Email: luciano@ifsc.usp.br

Abstract

The present work describes a novel system aimed at automatic contour extraction of 2D branching structures from 3D shapes, like neurons. Most of the 2D contour-based neuronal cell shape analysis approaches usually fail to suitably characterize them, since crossings between branches hinder the traditional contour extraction algorithm from entering the deepest cell regions. The herein-proposed method solves the aforementioned problem, by deciding upon the correct continuity across critical regions, thus having our contour following algorithm to gain full admittance into the cell image. Firstly, the original input image is preprocessed. After that, branch pixels are iteratively labelled, until attaining a critical region, when the algorithm determines the appropriate direction to continue. Lastly, our branching structures contour extraction algorithm successfully yields the corresponding parametric contour.

AMONG numerous approaches intended to characterize neuronal cells [1]–[3] geometry, the contour-based ones provide effective means for characterizing the respective shape. Such curves can also be used in an effort to derive the normal and/or tangent orientation fields along the cell contours and respective curvature (e.g. [4]), yielding information about the local degree of bending of the curve as well as its concavity. However, such an approach is often limited by the presence of crossings between the neuronal processes, causing some regions of the cell to become unreachable for contour extraction.

The current work is aimed precisely at solving such a problem, so that more complete parametric representations of the cell shape can be obtained and analyzed.

The proposed *Branch Tracking Algorithm* (**BTA**) approach involves two main steps:

- *Preprocessing* the input original image through mathematical morphology transformations, mainly yielding as output its 8-connected one-wide pixel *Skeleton*;
- *Labeling* iteratively valid branch neighboring pixels, until a *critical region* region is reached, when the algorithm takes a decision to continue with the tracking procedure for the current branch, besides classifying each *critical region*.

The proposed *Branching Structure Contour Extraction Algorithm* (**BSCEA**) finally takes as input the aforementioned outputs, to yield the desired parametric contour.

Figures 1(a) and 1(b) show as results a labeled image from a neuron alpha and its parametric contour, respectively. The original alpha neuron image was published in [5] and is used here under the license 1811020196460, October 16^{th} , 2007.

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REFERENCES

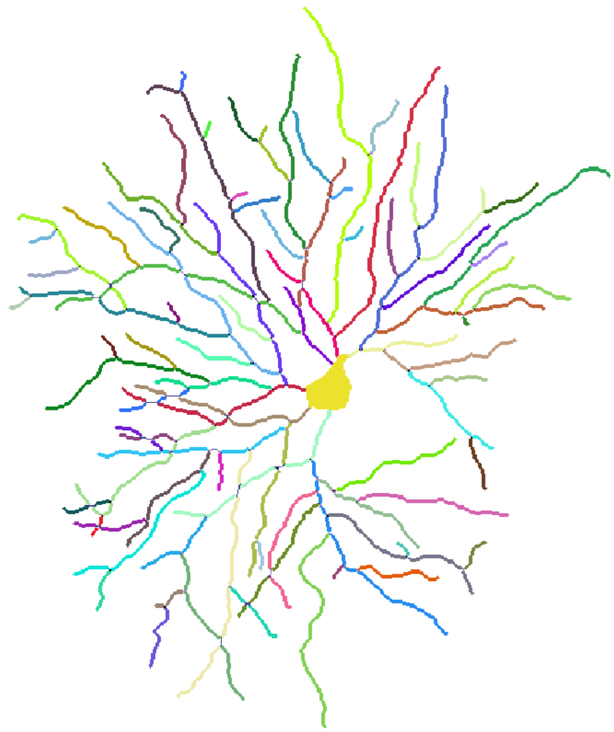
[1] H. Jelinek and E. Fernandez, “Neurones and fractals: How reliable and useful are calculations of fractal dimensions?” *Journal of Neuroscience Methods*, vol. 81, no. 1-2, pp. 9–18, 1998.

[2] L. da F. Costa, E. Manoel, F. Faucereau, J. Chelly, J. van Pelt, and G. Ramakers, “A shape analysis framework for neuromorphometry,” *Network: Computation in Neural Systems*, vol. 13, pp. 283–310(28), August 2002. [Online]. Available: http://www.ingentaconnect.com/content/tandf/network/2002/00000013/00000003/art00004”

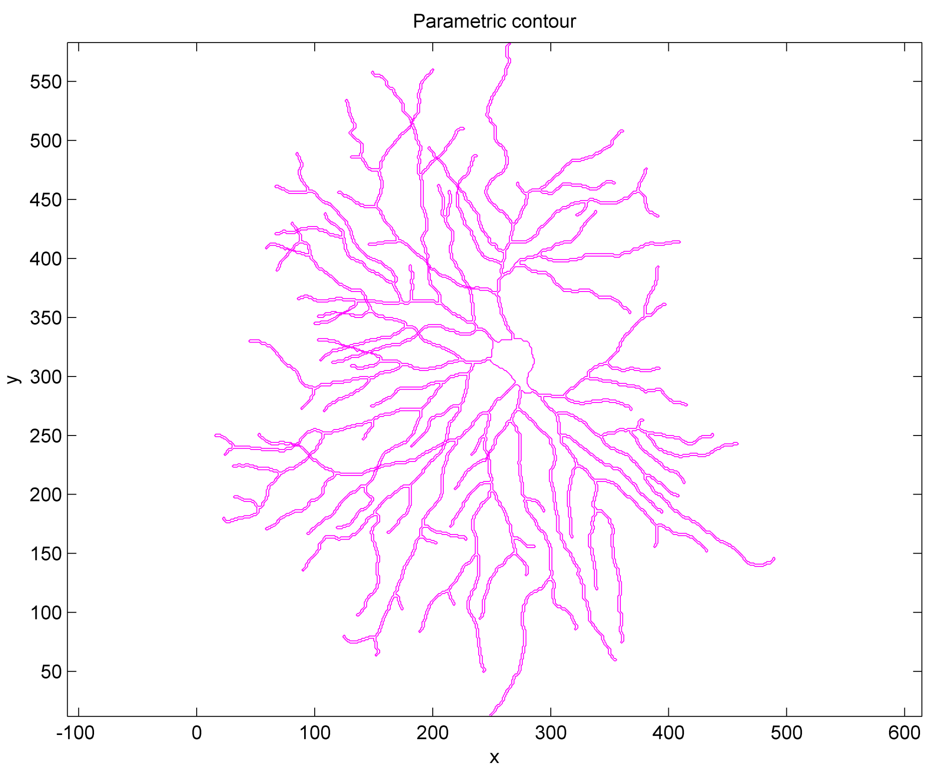
[3] M. B. L. Rocchi, D. Sisti, M. C. Albertini, and L. Teodori, “Current trends in shape and texture analysis in neurology: Aspects of the morphological substrate of volume and wiring transmission,” *Brain Research Reviews*, vol. 55, pp. 97–107, 2007.

[4] R. M. Cesar-Jr. and L. F. Costa, “Neural cell classification using wavelets and multiscale curvature,” *Biological Cybernetics*, vol. 79, no. 4, pp. 347–360, 1998.

[5] R. H. Masland, “The fundamental plan of the retina,” *Nature Neuroscience*, vol. 4, no. 9, pp. 877–886, 2001.



(a)



(b)

Fig. 1. (a) Image of an Alpha neuron labeled by the *BTA*. (b) Parametric signals $x(t)$ and $y(t)$ of an Alpha neuron image.