From snakes to inchworms: Adapting active contour models to discover line skeletons embedded in 3D volumetric data

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Goal

To create a fast and robust algorithm that can trace tree-like structures in 3D volumetric data.

Method

We will adapt an active contour algorithm to the problem of tree-like structure extraction from 3D data.

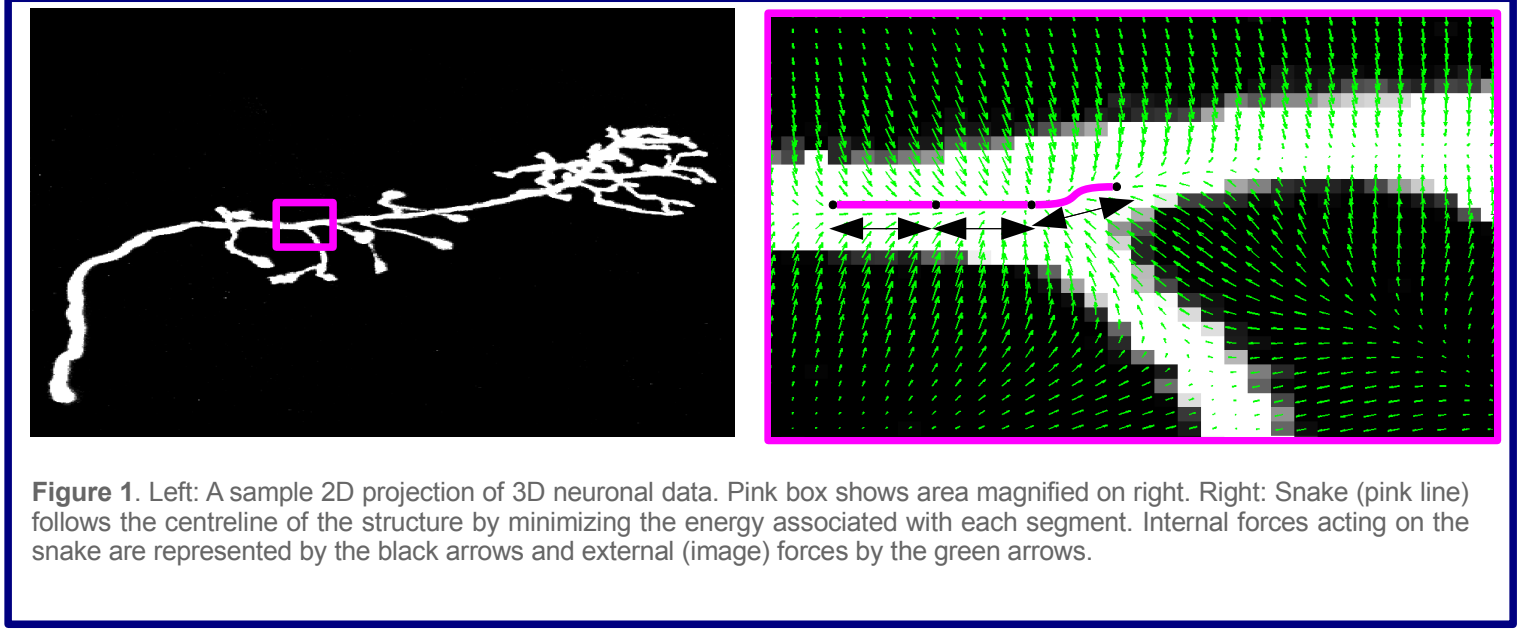

Figure 1. Left: A sample 2D projection of 3D neuronal data. Pink box shows area magnified on right. Right: Snake (pink line) follows the centreline of the structure by minimizing the energy associated with each segment. Internal forces acting on the snake are represented by the black arrows and external (image) forces by the green arrows.

Introduction

The "active contour" model (Kass et al., Int. J. Comp. Vis., 1988) sets up a loop of line segments ("snake"), each endowed with the physical characteristics of springs. The snake is initially in a stretched state, and is allowed to relax over time. Edges in the image exert a "force" on the snake, preventing it from contracting further which results in the "snake" discovering the 2D outline of an object.

We propose creating an "inchworm". First the image will be filtered in order to create a vector plot with vectors pointing to the structure of interest. Starting at one end of the line structure, the inchworm initially comprises 3 connected segments. The head of the inchworm can detect the vector field, and grows in the direction of least resistance. When the head is fully grown, an extra, compressed segment is added, and then allowed to grow to its full length.

The inchworm can be endowed with varying levels of stiffness, which can be used to smooth out noise in the line. Also, if there are short gaps in the line, the inchworm will continue to travel in the same direction, and may therefore be able to discover the next line segment.

Outcome

We expect that this algorithm will provide a fast and robust way of extracting skeletons from 3D data. Leading on from this project we hope to:

- release the algorithm as a plugin for ImageJ (an open source image processing toolkit, http://rsbweb.nih.gov/ij/)
- integrate this algorithm into an automated neuron tracing program we have been helping to develop
- publish the results in a journal or present them at a conference
- use the results as a proof of principle in order to seek extra funding to develop the algorithm further.

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