

# New tools to analyse synaptic density and neuronal structures



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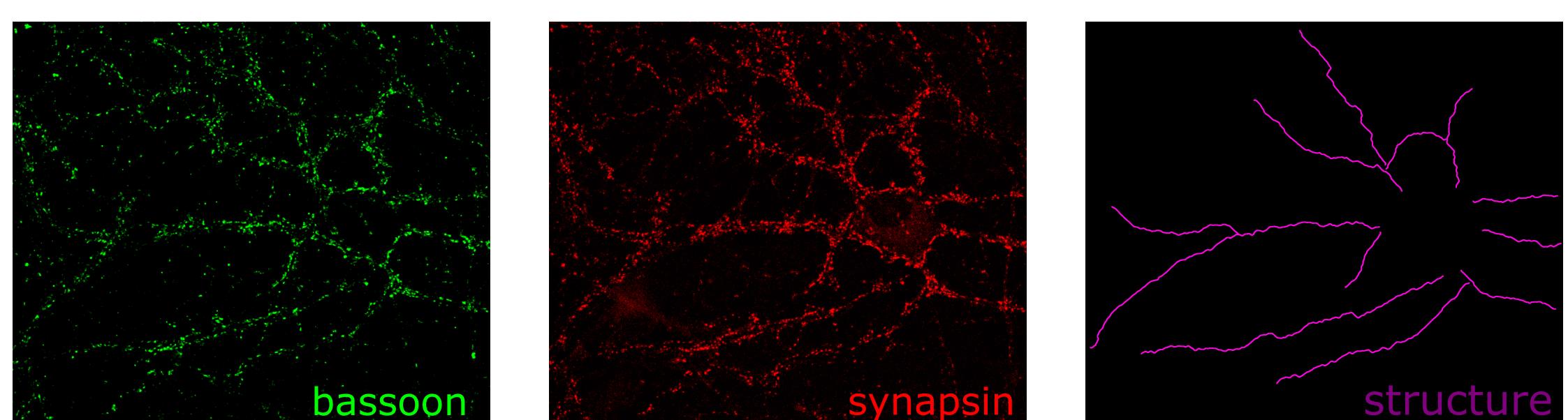
## Abstract

The aim of our work consists in developing software systems which allow a full automation of research, integrating from the management of microscope movement to the final analysis of spine and synaptic density. The underlying algorithms of these programs are based on both homological methods for digital imaging and geometric persistence models.

All our plugins have been implemented in Java for the systems *ImageJ/Fiji*, and can be executed in Windows, Mac OS X and Linux.

## SynapCountJ

This plugin provides an automatic solution to measure synaptic density. The underlying method of this plugin is able to identify synapses thanks to a triple criterion: two synaptic markers and a neuronal morphology marker.

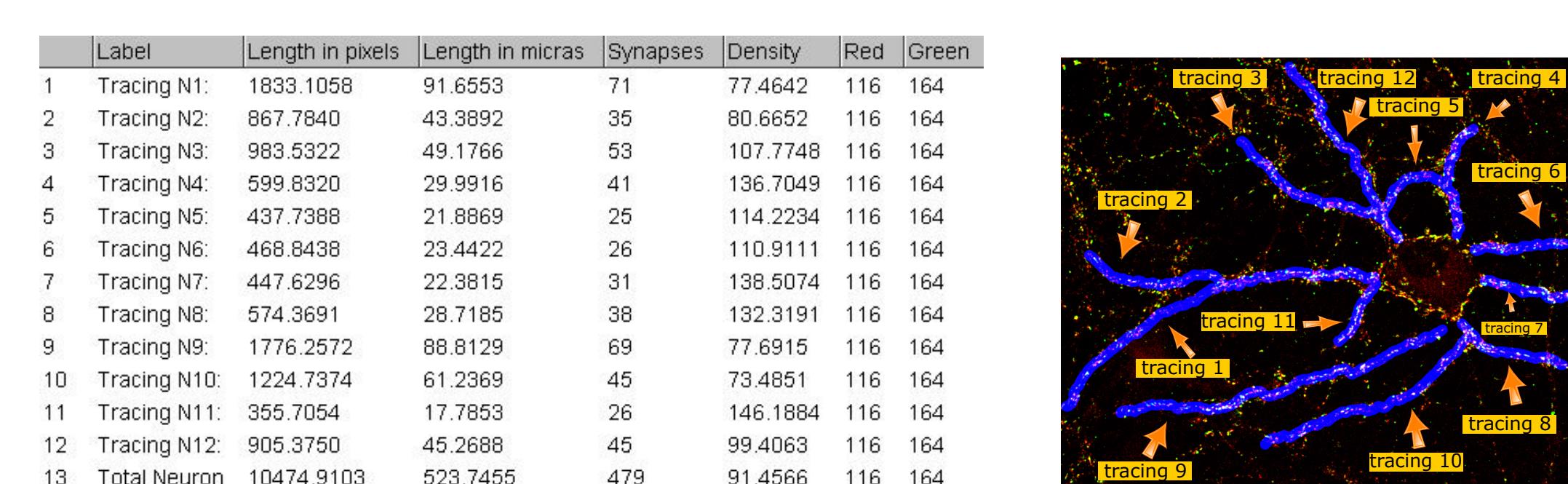


We select the regions where the measurements are going to be performed using the NeuronJ plugin. In this way, we remove the background.

*SynapCountJ* overlaps the two original images and the structure (selected region). The plugin identifies the white points as candidates to be synapses. The plugin allows the user to modify the values of the red and green channel in order to change the detection threshold and obtain a first image where such points are marked (red points in the image) for a further counting. *SynapCountJ* updates automatically the amount of synapses which has been computed when modifying the threshold.



Eventually, *SynapCountJ* returns a table with the obtained data and two images showing, respectively, the analyzed region and the marked synapses (blue crosses).

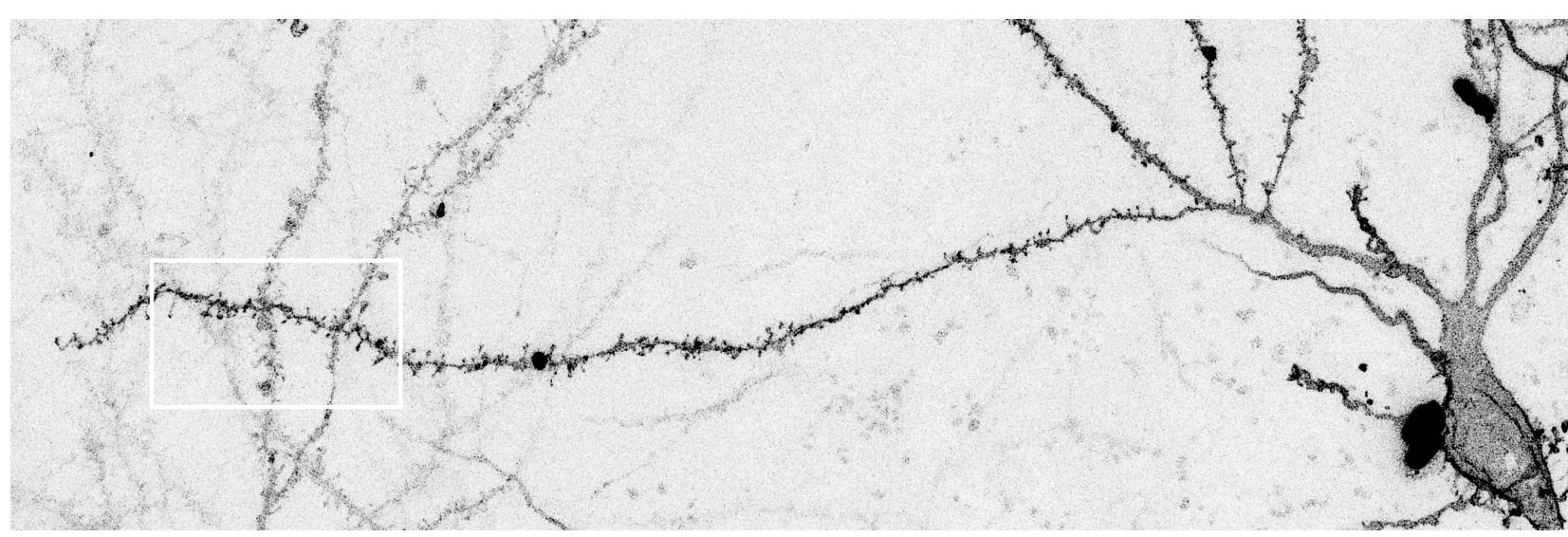


From the threshold data obtained from a individual neuron, the program generates a file with the information which can be applied in batch processing for all images. Notice that pictures obtained from the same experiment have similar settings. In this way, batch jobs can be carried out inside *SynapCountJ*.

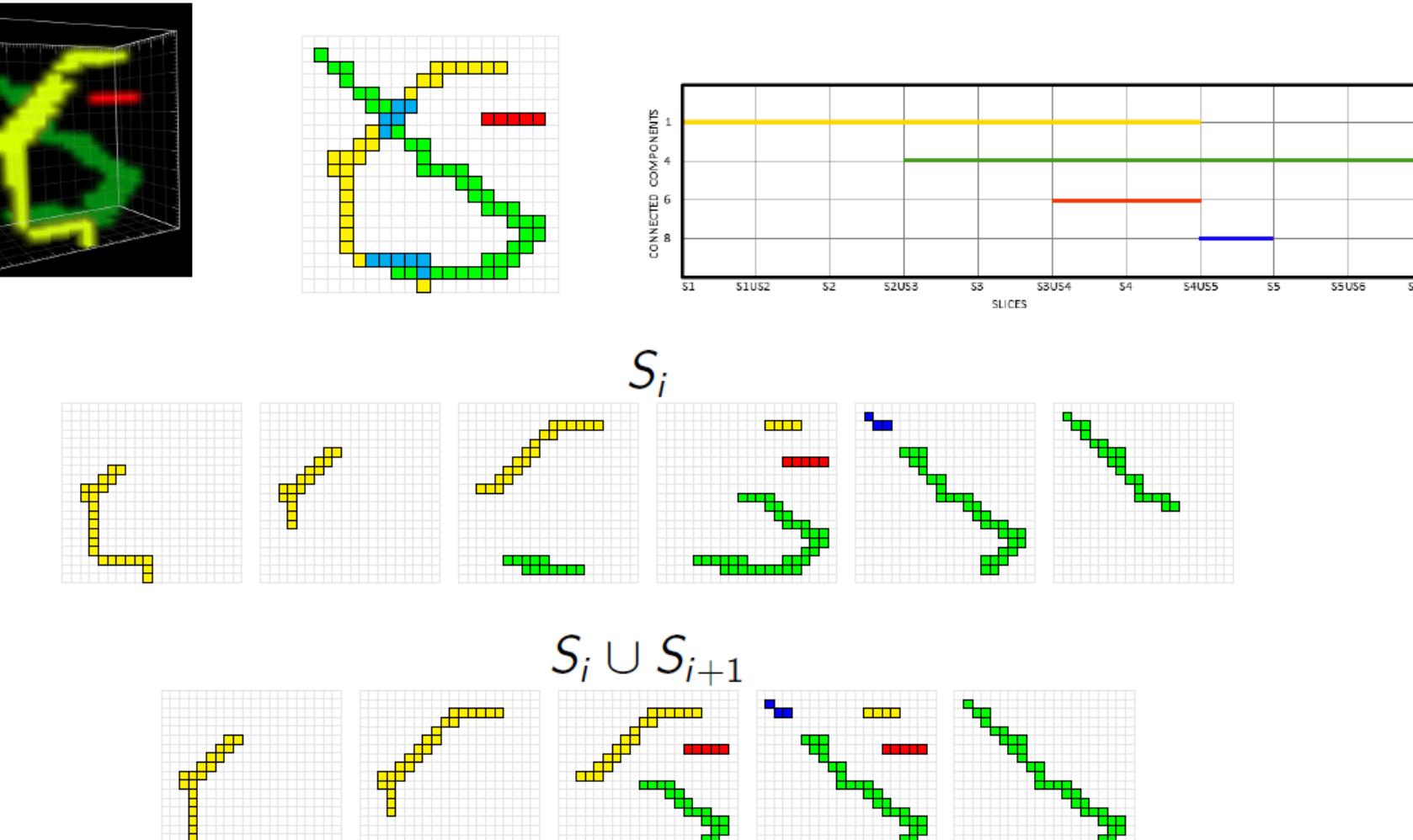
You can get more information and download the plugin from  
<http://imagejdocu.tudor.lu/doku.php?id=plugin:utilities:synapsescountj:start>

## NeuronZigZagJ

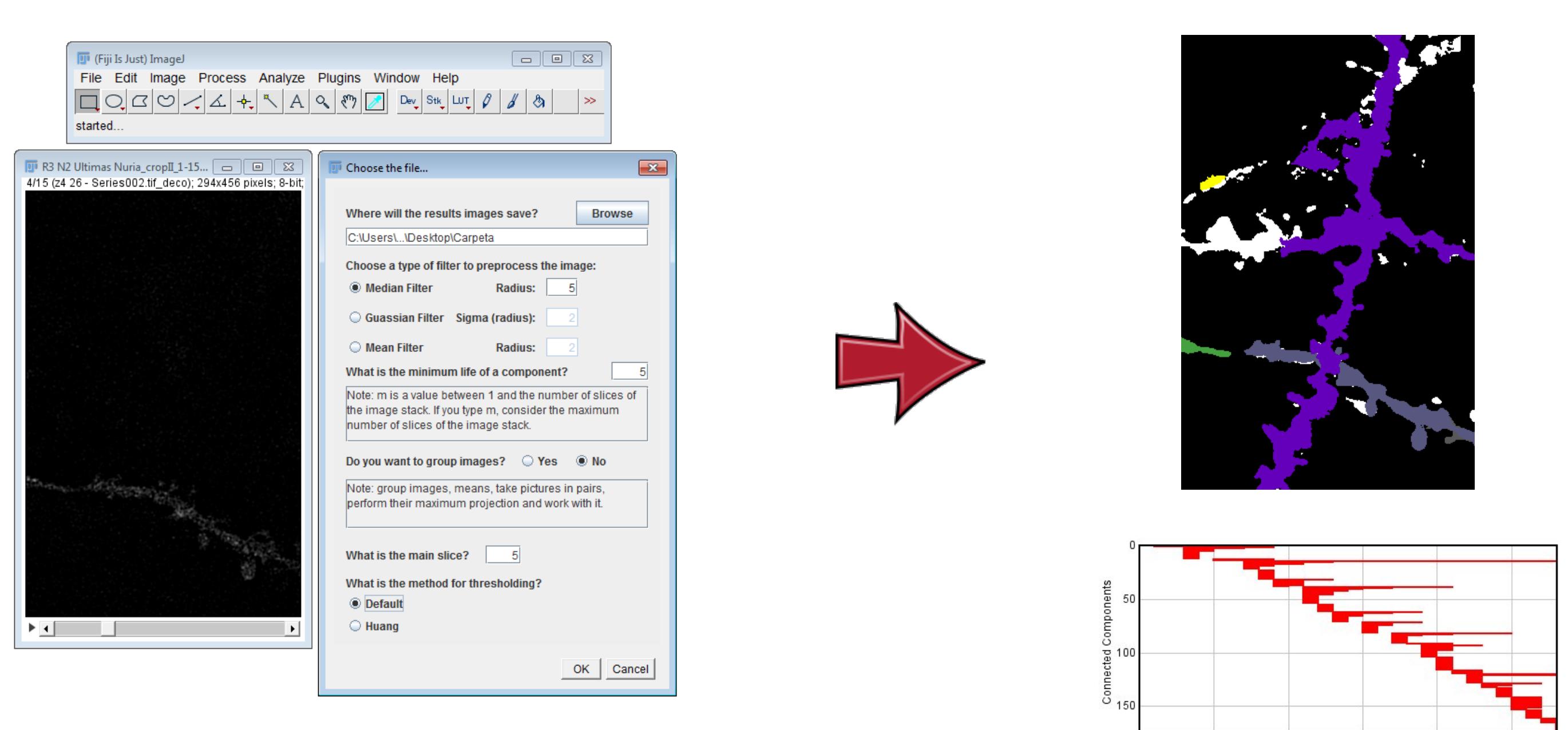
The goal of this plugin is to determine the structure of the neuron by the different planes of a stack image.



When the maximum projection is carried out, some parts of a neuron are overlapped with others. This plugin helps to isolate the object of interest using the theory of zigzag persistence.

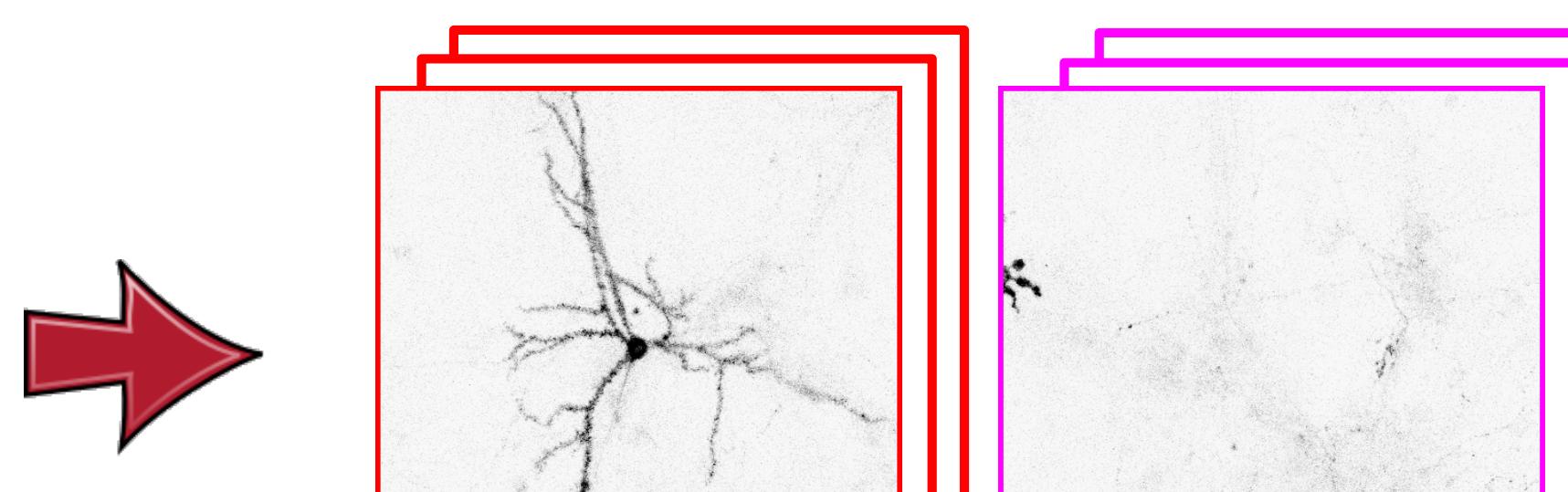
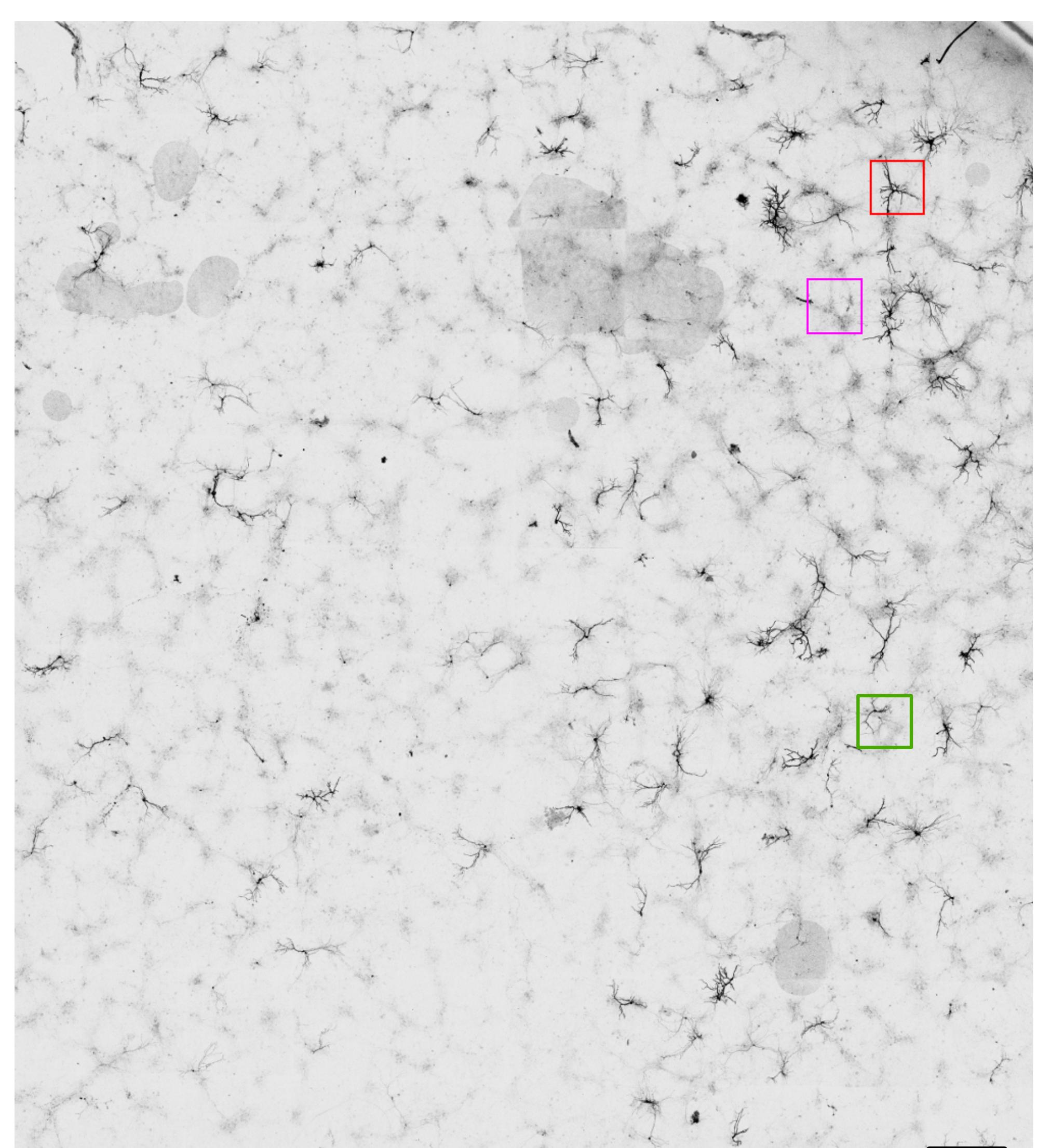


The zigzag persistence theory states that joining these slices in an operation (for instance the union of slices) and doing the study of the component's lifespan in all slices, we can know the number of components that are in a stack of images.

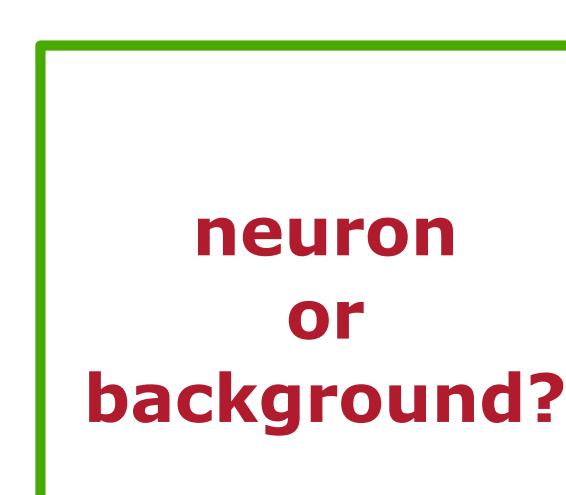


For a more detailed explanation see  
G.Mata,M.Morales,A.Romero,J.Rubio. Zigzag persistent homology for processing neuronal images.Pattern recognition Letters 62,55-60.2015.

## Current work: High-Content Analysis in Images of Neurons



Machine Learning Techniques



Steps:

- Extract the features of each patch of the image.
- Use algorithms of Machine Learning algorithms to train and test the patches obtained.
- Analyse the data to know which is the best method with the best features to classify images like these.

The images used are 2D confocal images, the size of each image is about 10,000 x 12,000 px, covering about 70mm<sup>2</sup> of culture dish. These images contain on average 40 GFP transfected neurons.

For a more detailed explanation see  
G.Mata,M.Radojevic,I.Smal,M.Morales,E.Meijering,J.Rubio. Automatic detection of Neurons in High-Content Microscope Images using Machine Learning Approaches. ISBI,330-333.2016.

Work in collaboration with:



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