Segmentation and detection of extended structures in low frequency astronomical surveys using hybrid wavelet decomposition

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Abstract

The morphological complexity of extended real structures (such as SNRs, HII regions, bow shocks, etc), and their wide variety in scale and surface brightness make their automatic detection and segmentation in large surveys a difficult task. We propose in this paper a segmentation method based on applying wavelet decomposition in the residual thresholded images. This strategy avoids the artifacts produced by strong sources in a straight wavelet decomposition. Our method successfully segments extended structures at different scales and therefore is suitable for further morphological analysis and object recognition processes. Results using images from radio and infrared wavelengths surveys demonstrate the validity of our approach.

1. Motivation and objectives:

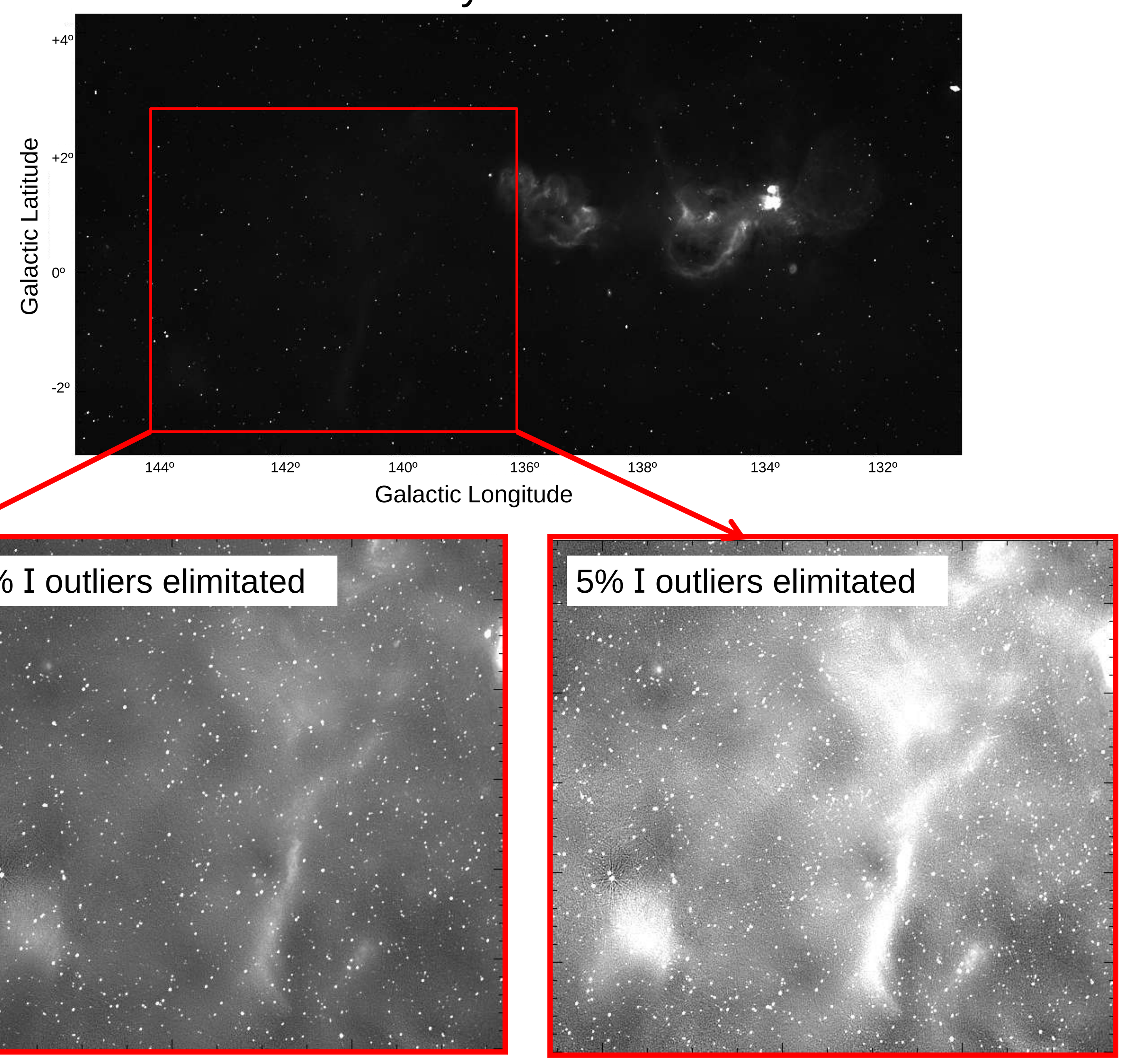
To illustrate our method we use the images from the Canadian Galactic Plane survey in the figure below.

It can be seen that:

- Large surveys reveal thousands of low frequency emitting objects.
- Many of these sources are associated to extended complex structures, shown at different intensity scales.

CGPS VWXY mosaics, 1420 MHz, continuum

0.1% intensity outliers elimitated

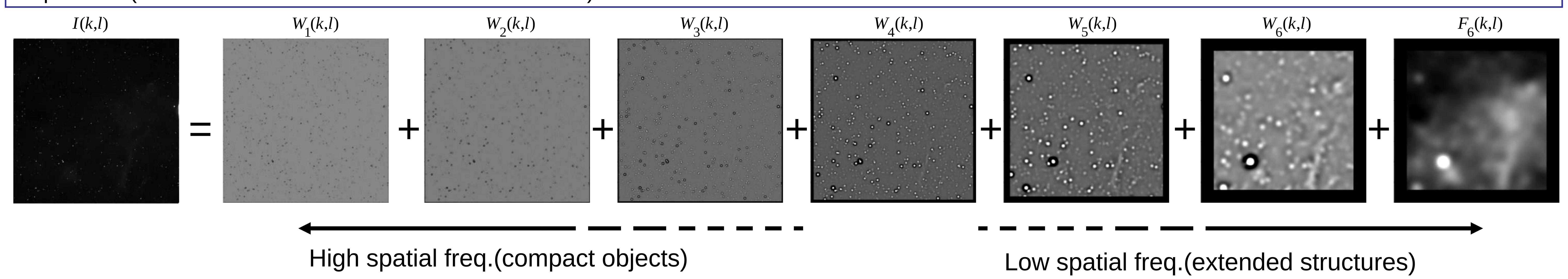


Zoomed area around Lynds Bright Nebula 679

Our objective is to automatically detect and segment these extended sources for further catalogation and morphological analysis. However, their rich variety of morphologies and surface brightness makes them elusive to automated detection methods, such as region growing based algorithms or contour detection based algorithms.

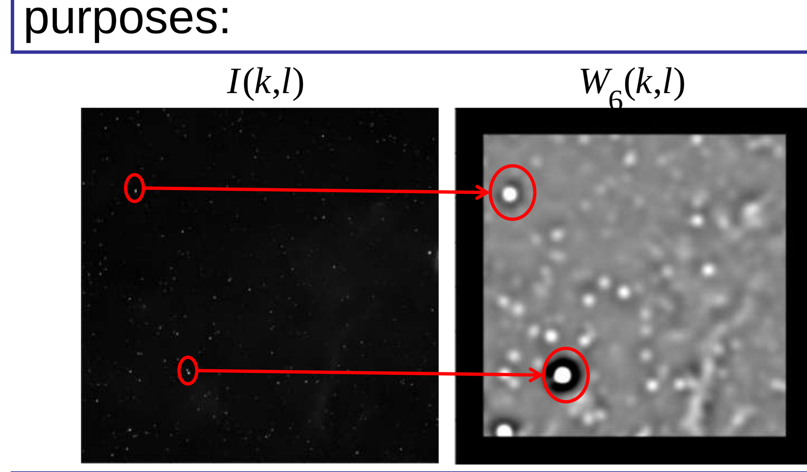
2. Wavelet decomposition of the sample image using the "à trous" algorithm

Multiscale Vision Models decompose an image in J scales or wavelet planes and segment independently each of the images representing a scale. To illustrate this we show the decomposition of the image in 6 scales plus the smoothed array using the "à trous" algorithm with a B_3 spline filtering function. As it can be seen, low index scales emphasize high spatial frequencies (which translates to compact objects in case of true signal). High index scales emphasize low spatial frequencies (in this case emission from extended structures).



3. Problems and proposal

As an example, we could use the image corresponding to one of the last scales in the decomposition for a more clear display of extended emission or for detection purposes:

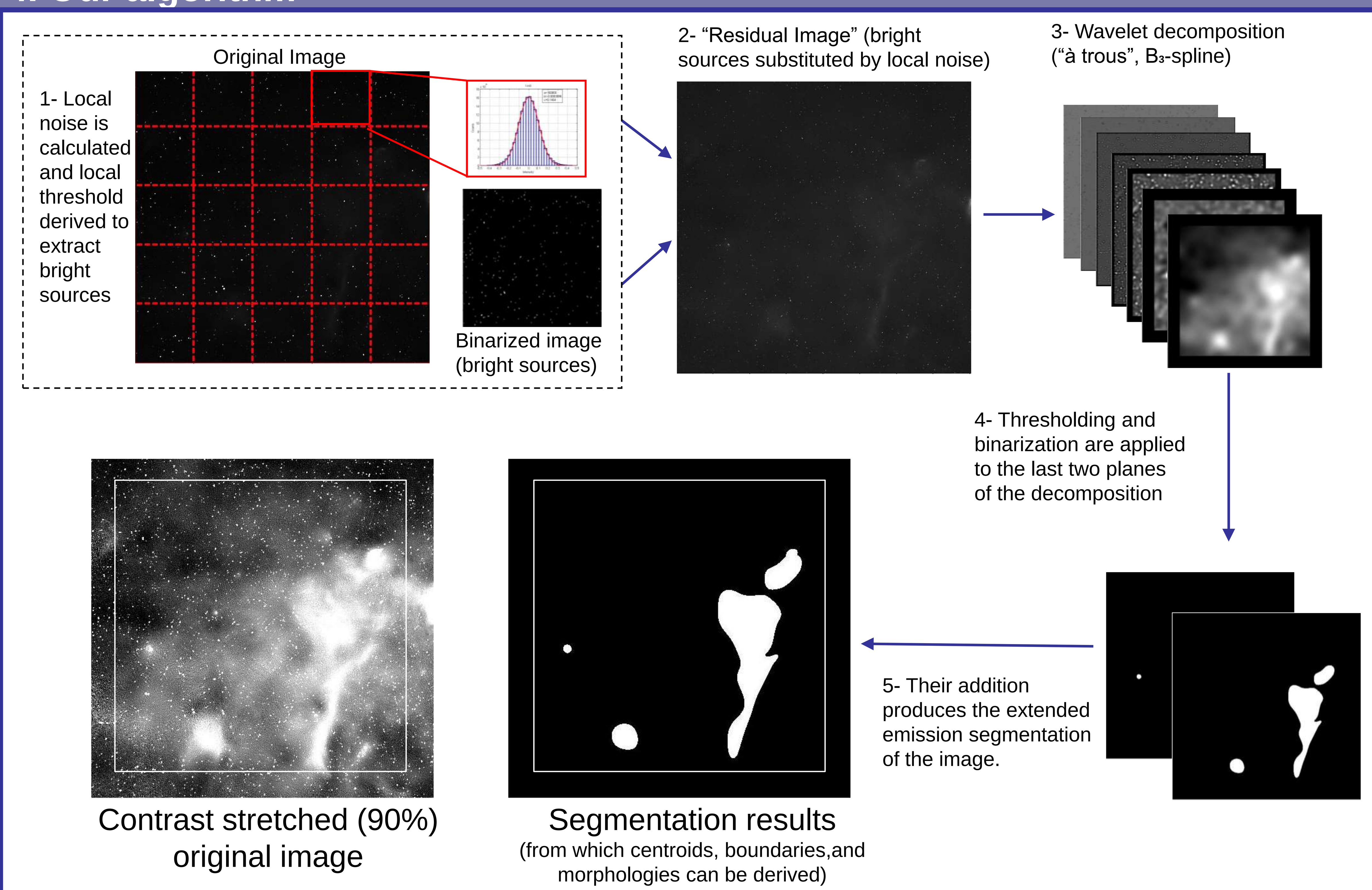


PROBLEMS:

1. Due to their high brightness, strong compact sources are not filtered out and show up in low spatial frequency planes.
2. To keep the wavelet coefficient mean at zero, negative artifacts around these strong structures appear and pollute the whole image.

WE PROPOSE to create an image where bright sources are substituted by local noise. Wavelet decomposition will then be applied to this new image in order to detect fainter extended structures.

4. Our algorithm



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