Automatic Detection & Description of Solar Filaments on Hα images

N. Fuller and the HELIO team

l'Observatoire de Paris — LESIA
Laboratoire d'Études Spatiales et d'Instrumentation en Astrophysique

Main Objectives

- to automatically detect filaments on standardized full Sun Hα images using region growing
- to describe the segmented regions using morphological operators and to retrieve parameters such as coordinates, length, skeleton, boundary, chirality, etc.
- to populate the HFC (Heliospheric Feature Catalog) in the frame of the european HELIO project

Image Processing

The segmentation process consists in the following steps:

- Removal of non-geometrical intensity variations by subtraction of an approximated background (multiple median filtering)
- Dust line removal if necessary and sharpness enhancement (Laplacian filtering)
- Seeds detection by a windowed threshold and region growing in the seed area
- Connect close filaments with a closure operator and remove small, isolated and faint features by a new weighted scoring method

NB: This work was initiated within the EGSO project. More detailed information about these steps can be found in: Fuller, N., Aboudarham, J. & Bentley, R., Filament Recognition and Image Cleaning on Meudon Hα Spectroheliograms, Solar Physics, 227, 61-75, 2005

Gray Scale Skeleton :

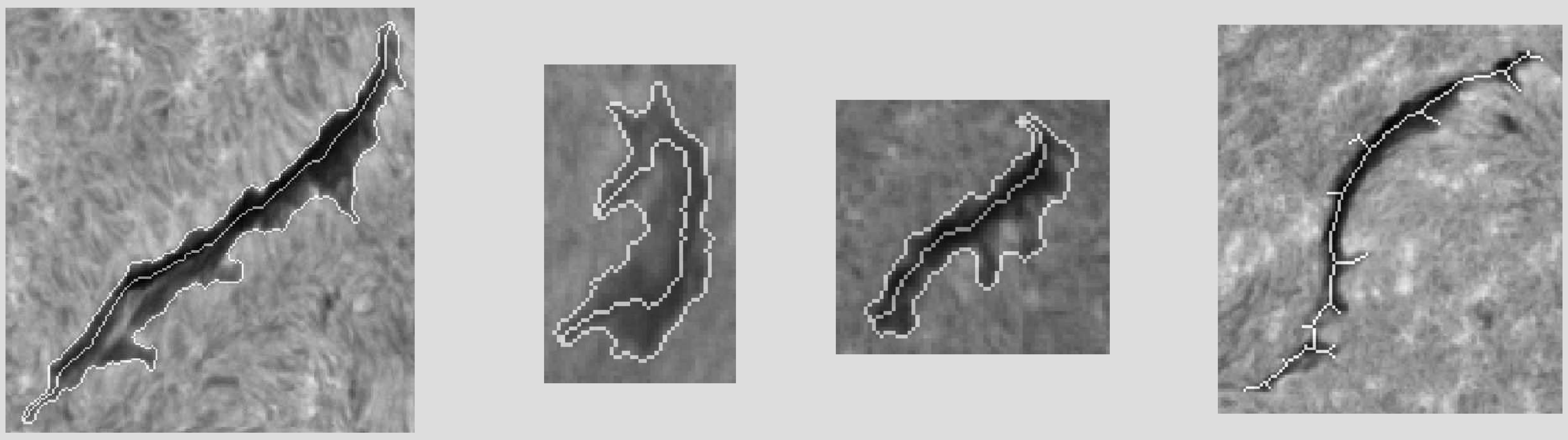
The previous method used to compute the filament skeleton was based on a thinning operator applied to a binary shape. The new algorithm takes into account the gray scale values of the filament in order to better sketch the filament's darkest areas. As a result the spine (pruned skeleton) is not biased by filaments barbs for example.

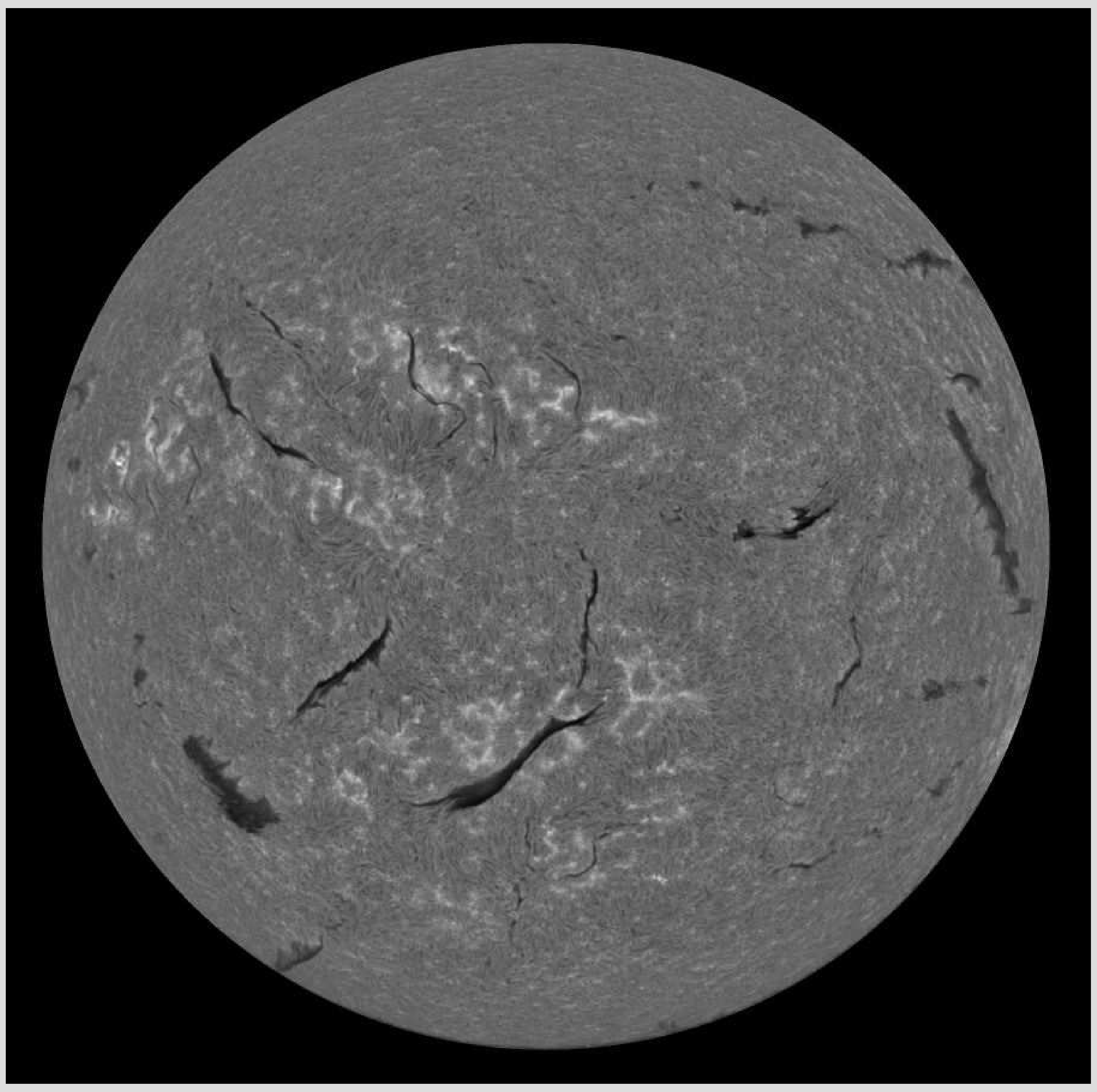
The thinning operation is calculated by translating the origin of a structuring element to each pixel position on the binary shape. If the foreground and background pixels in the structuring element exactly match foreground and background pixels on the shape, then the pixel is set to zero. This operator is applied repeatedly until convergence (i.e. one more pass produces no changes). (see Gonzales & Woods, Digital Image Processing)

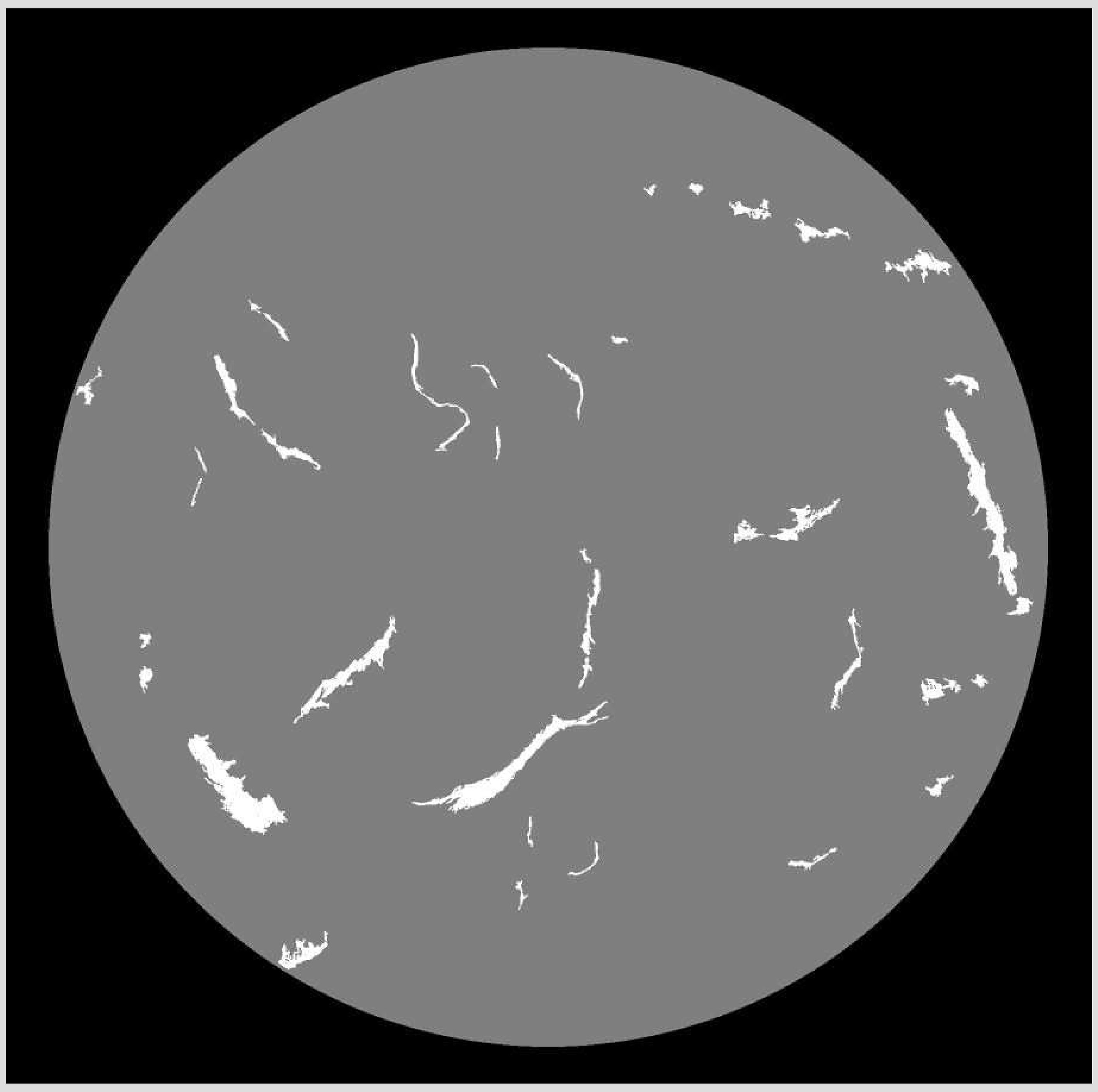
In the new version an additional condition must be fulfilled to set the pixel to zero: its value must lie in a previously defined gray level range. The algorithm starts from the highest values and ends with the darkest areas of the region.

There are some drawbacks to such a method compared to a simple thinning: it is a little slower (but no big difference), gray scale ranges must be set prior to thinning (which partition will give the best results ?), gray level discontinuities could create spurious branches (as pepper noise for a binary shape). One way to overcome the former issue is to previously smooth the region values. We fine tuned our algorithm with respect to these questions and get the results we expected on a representative set of images.

The spine is then obtained by a new pruning algorithm which removes short branches from the skeleton tree. A chain code is then computed from the remaining pixels and stored in an ascii file with other parameters. Some spine examples are shown below.







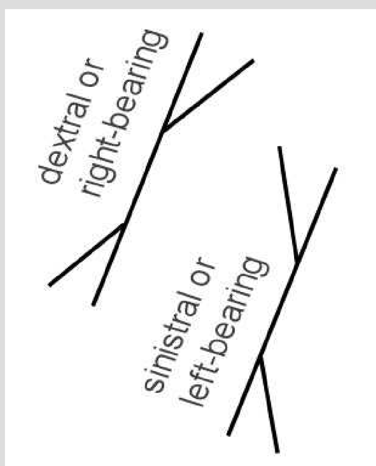
Segmentation results for the 11th of September 2000 (BBSO)

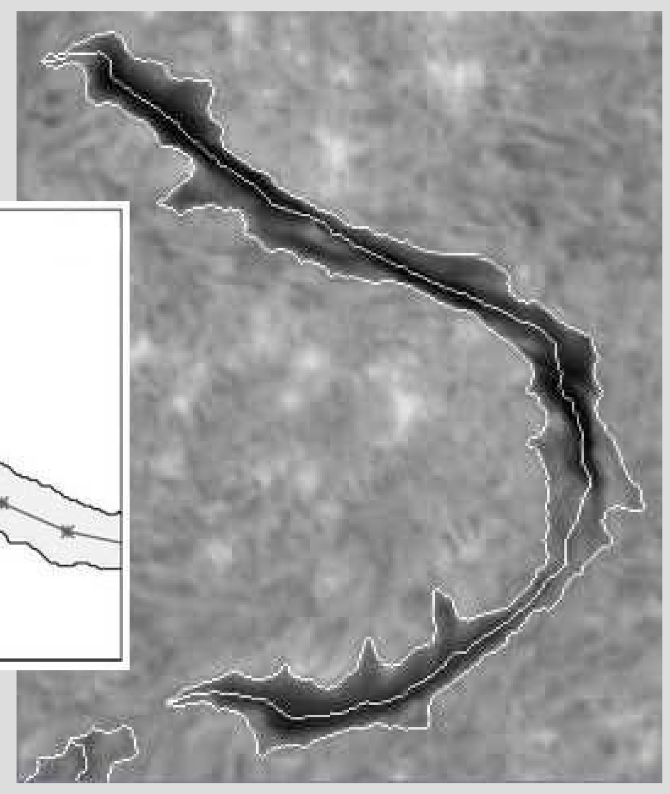
Chirality:

The filament barbs (or feet) could be seen as "ramps of an elevated highway" (Bernasconi *et al.*, 2005), the highway being the dark core of the filament. From the orientation of these barbs one can determine the sign of the magnetic helicity (flux rope twist). In the case of an erupting filament this parameter is an indication of the magnetic orientation of the CME. Since the orientation of the CME at Earth is one of the main factors determining its geoeffectiveness, chirality might be a valuable addition to the HFC. For a physical discussion about the barbs and the magnetic helicity see Aulanier & Demoulin (1998) for example.

The orientation of barbs determines the chirality, as shown on the sketch on the right. Since both orientations can be found in a given filament, Pevtsov *et al.* (2003) introduced the fractional chirality given by Cf=(Ndex – Nsin)/(Ndex + Nsin). We tried to use the information given by the branches of the skeleton (see above) to determine this number. For every branch we compute the angle between the branch and the local spine and sum these contributions to compute Cf. The preliminary results are not satisfactory enough to conclude on the effectiveness of such a method.

Another possibility is to use the method proposed by Bernasconi *et al.* They compute the distance between the boundary and the spine and, using an appropriate threshold, determine the barb candidates. Using the baseline of the barb, they compute its orientation (see the example on the right). The determination of the spine appears to be more accurate using the method described above compared to Bernasconi's method (at least on the examples we have). This method might hence contribute to an improvment of the barbs identification, and thus to a more precise determination of the chirality.





Conclusion & future work:

The method we developed to detect filaments on full disk Hα images proved to be effective. The example given above shows that all filaments have been correctly detected, even small ones. Compared to the previous version, we enhanced the way ambiguous features are kept or discarded and give a more accurate representation of the filaments's spine. Considering the importance that might have the chirality parameter in terms of space weather, we wish to investigate further the methods that could efficiently provide it. The catalog we are building would not be complete without any information about the time evolution of these filaments. In the frame of the HELIO project, Bonnin *et al.* developed an efficient way to track filaments during their transit accross the solar disk.