

The Sun has been observed since 1870 in Meudon Observatory. On a regular basis, pictures of the Sun have been taken since 1909, resulting in a centennial archive. Similar archives are also available in other places, giving a unique opportunity to study our star for more than height solar cycles. Provided that these observations are available in a digital format (about three cycles in Meudon, still growing), automated detection tools can give a new insight on these time series, for statistical studies for example. They could also be a way to generate alarms from real time or near real time observations ('disparitions brusques' for example, see Trackfil software [1]). The tools which are shown here have been designed to be applied to standardized Sun images and tested on Meudon ($H\alpha$, CaIIK3) and BBSO ($H\alpha$) images. The results are stored in HELIO's Heliospheric Feature Catalog (HFC [2][3]).

Main Objectives

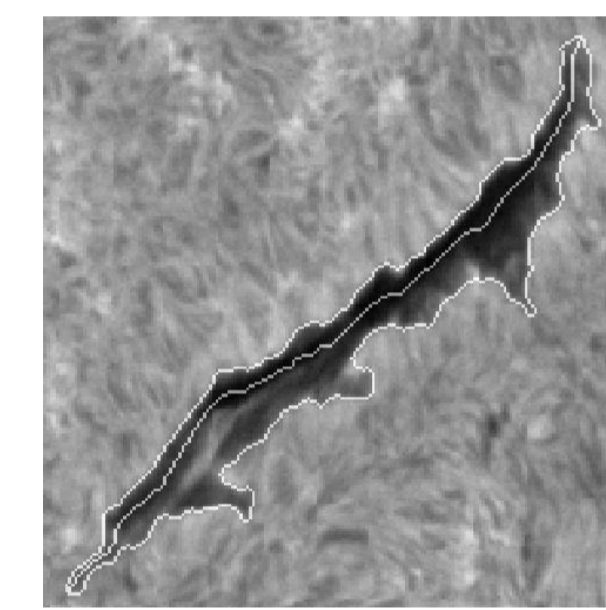
- to automatically detect filaments & prominences on standardized full Sun $H\alpha$ and CaK3 images
- to describe the segmented features using morphological operators and to retrieve parameters such as coordinates, length, height, skeleton, boundary, raster scans, etc.
- to populate the HFC (Heliospheric Feature Catalog) in the frame of the European HELIO project

SoSoFT : Segmentation of Solar Filaments using $H\alpha$ spectroheliograms

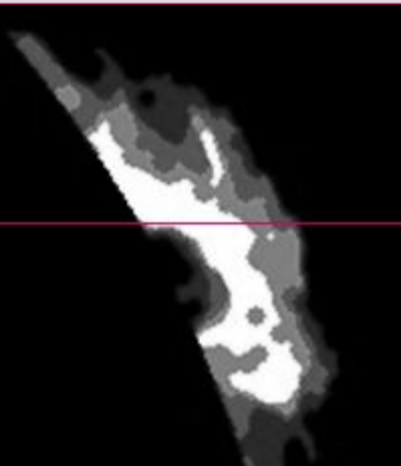
The segmentation consists in the following steps, which are more detailed in [4]:

- 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.
- Connection of close filaments with a morphological closure operator.

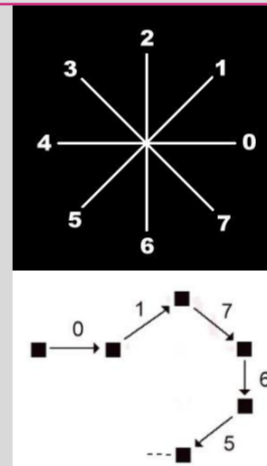
More recently we added a new step which purpose is to remove small, faint and isolated features and also to distinguish filaments from potential sunspots. This is achieved using a weighted scoring method, which takes into account parameters like: size, intensity, elongation and distance to other features.



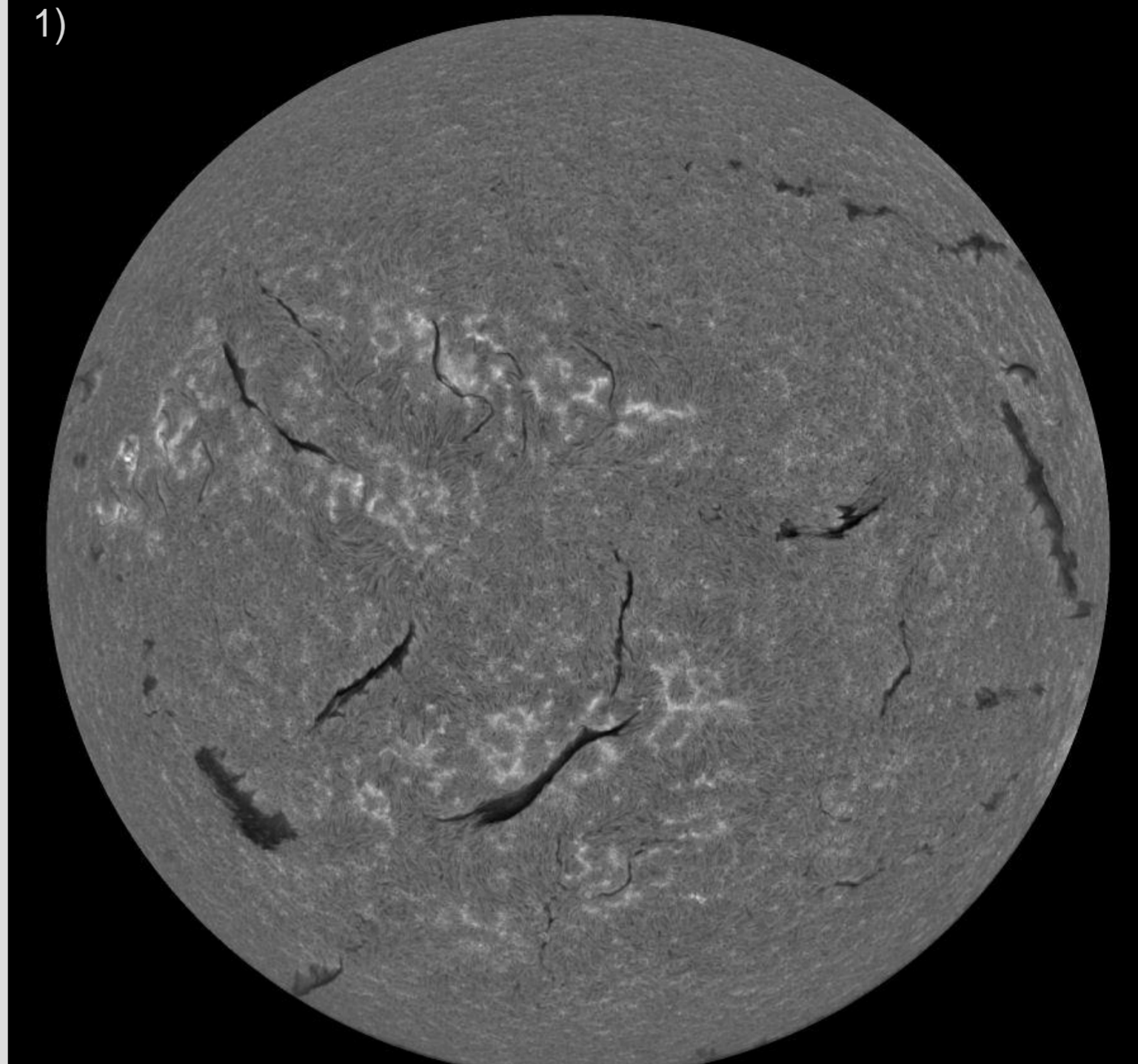
We also enhanced the way the skeleton of the filaments are computed: the previous method was based on a thinning operator applied to a binary shape, whereas the new algorithm takes into account the grey scale values of the filament in order to better sketch the it's darkest areas. The result of the thinning process is a tree with spurious branches which are removed according to the grey scale value of their neighbourhood. Consequently, the final "spine" (pruned skeleton) is not biased by filaments barbs as shown on the example. A chain code is then computed from the remaining pixels and stored in an ascii file with other parameters. The whole process duration is about 10s, depending on the number of features on the image. 14 years have been processed so far representing more than 5000 images.



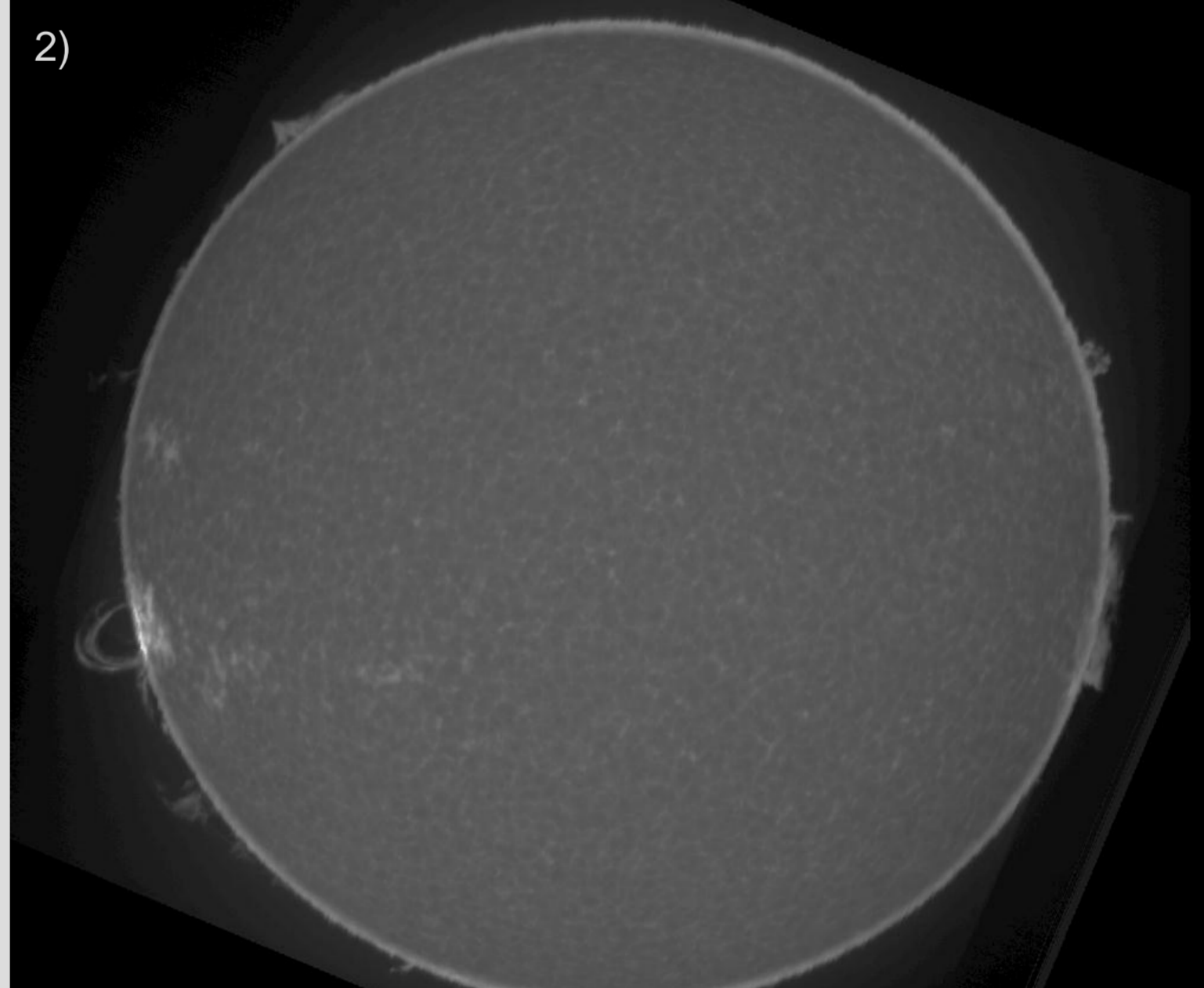
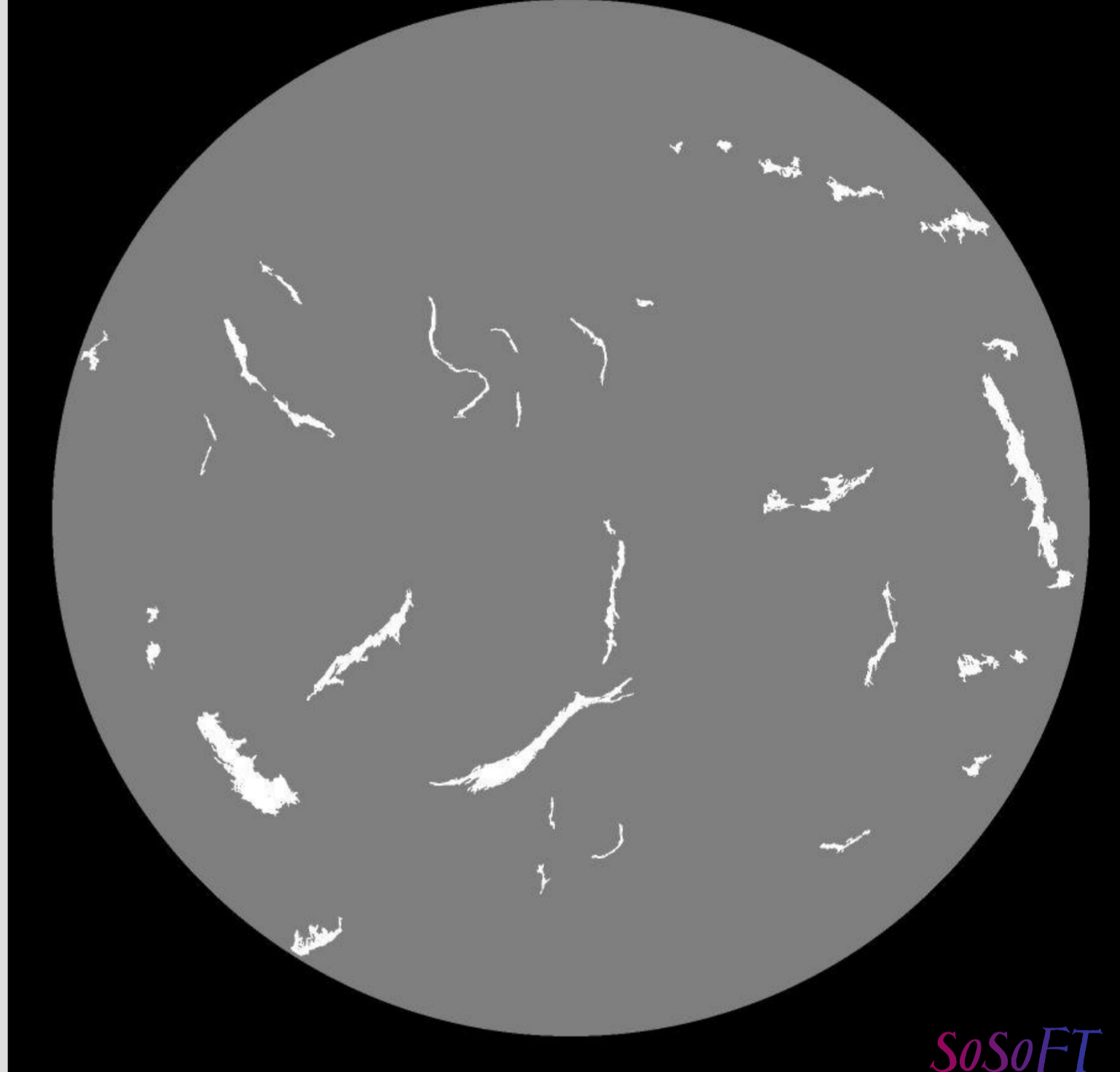
Run Length Encoding is a simple compression algorithm in which *runs* of data (that is, sequences in which the same data value occurs in many consecutive data elements) are stored as a single data value and count. It is useful if we reduce the grey levels to a small number like in the example on the left side (5 levels). One line then looks like: **043.422.37.25.11.023**;



The Chain Code is a sequence of numbers corresponding to given orientations: "01765511...." for the example on the right side. From the position of the first pixel, all the skeleton/boundary can be restored from the chain code (i.e. we don't need to store every pixel coordinates).



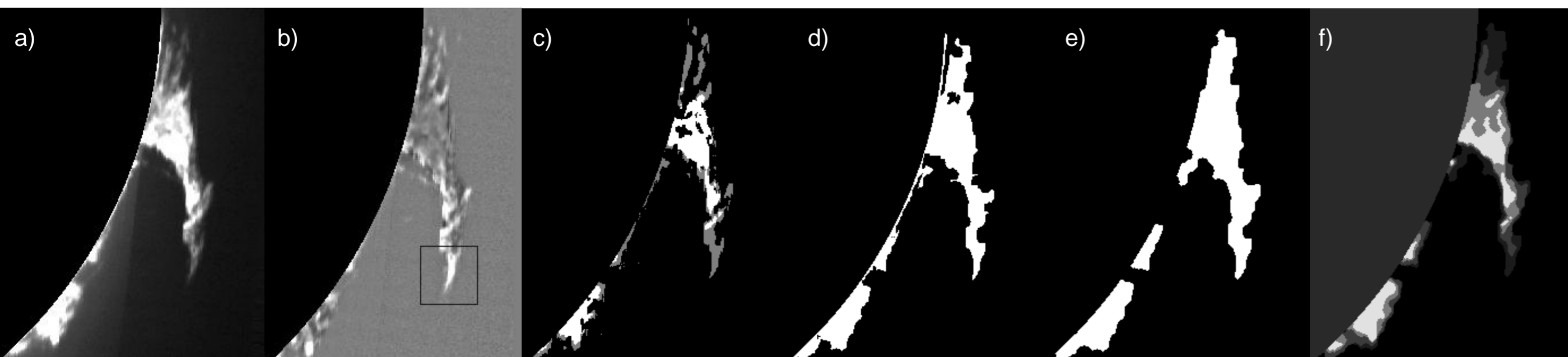
Segmentation results for the 11th of September 2000 (BBSO)



Segmentation results for the 8th of September 2005 (Meudon)

SoSoPRO : Segmentation of Solar Prominences using CaII K3 images

To detect the prominences we use the same kind of tools as for filaments, but without any preliminary background normalisation. Indeed, for these images, the background is varying both radially (but not homogeneously see fig. 2), and also in a step like way (see fig. a). It is thus rather complex to compute the background properly. To retrieve some seed pixels in such an image, we first use the property of the median filter (MF): Original image (a) is divided by the MF of (a) to give (b), where both radial and step-like variations are reduced. In addition, the faint and isolated parts of the prominence (like the 'beak' inside the square) are sharpened thanks to the MF. To include these faint parts in the segmentation, a threshold is computed iteratively from (b), with condition on the number of regions resulting from that threshold. Another threshold is computed from the original image to get the pixels with the highest values ($> \text{Med} + 5 * \text{MedAbsDev}$). Those pixels are depicted in white in (c), whereas the first ones are in grey color. All of them are then used as seeds within a growing region process which is controlled both by the intensity of the neighborhood pixels and by the size of the resulting region (d). The next step is to remove some spurious pixels in (d) which are due to the high intensity of pixels near the limb. We use a morphological erosion together with a closure operator to get (e) which is the final segmented region. Like we did for filaments, we compute a chain code for each prominence, but this only draws the boundary of the features. To save the information about the intensity variations inside the prominence (f), we use a run length encoding compression algorithm. The whole process runs in about 5 to 10 sec.



Conclusion & future work:

Prominences: a hundred observations have been processed so far but the number will grow rapidly as SoSoPro demonstrated it's efficiency. It will be included in the HFC (see also J. Abouadarham's poster) before the end of 2011. Next step will be to match prominences on the limb with filaments on the disk. **Filaments:** the method we developed proved to be effective on a large set of images (1997-2011) which are already available through the HFC. Compared to the previous version, we enhanced the way we discard ambiguous features and give a more accurate representation of the filaments' spines. Next step will be to apply SoSoFt to a larger set of BBSO observations.

[1] X. Bonnin et al., submitted to Solar Physics
 [2] HFC web address: <http://voparis-helio.obspm.fr/hfc-gui/index.php>
 [3] Jean Abouadarham et al., EGU General Assembly, 2011
 [4] Fuller, N., Abouadarham, J. & Bentley, R., Solar Phys., 227, 61-75, 2005