



## Deliverable report

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Abstract      **This report summarizes the work done on Image thresholding of the Fresh WP2**

Keyword List      WP2, image thresholding

## 1. CANNY EDGE DETECTOR ALGORITHM

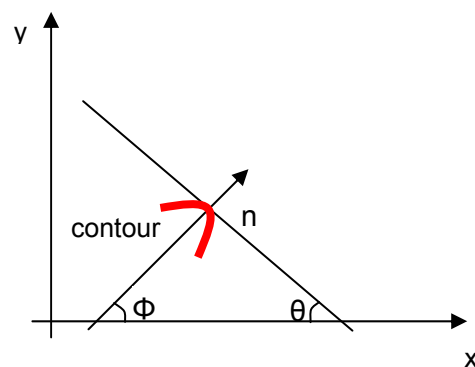
Pixels from edges are areas of relevant variation of the information. That's why the grey-level variation must be computed for each pixel. There will be an edge when the gradient will be a local maximum.

The gradient for a pixel of a numerical image is a vector characterized by its magnitude and its orientation. So the easiest method to estimate a gradient consists in the monodimensional variation, that's to say by choosing a given direction.

As the gradient is a vector, the best approach to estimate it consists in choosing two privileged perpendicular directions, where the gradient is projected.

The magnitude is directly related to the local variation quantity of grey-level.

The gradient direction is perpendicular to the boulder of the pixel under consideration



The approach presented, is based on Canny's edge detection who proposed an edge detector. The detector should satisfy three criteria:

1. Detection : the edge detector must found all edges and only edges. It must be strong for the noise.
2. Localization : it must be as precise as possible.
3. Answer : the edge detector should not identify multiple edge pixels where only a single edge exists.

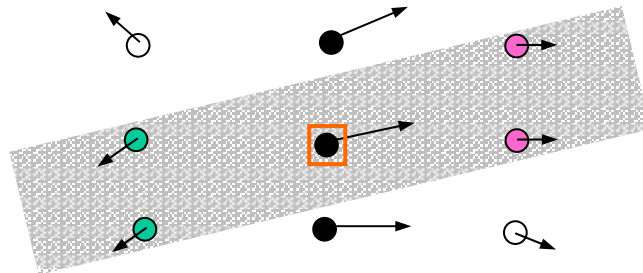
The mathematical expression of the three criteria is:

- The edge detector should respond only to edges, and should find all of them. No edge should be missed (Error rate).
- The distance between the edge pixels found by the edge detector and the actual edge should be as small as possible (Localization).
- The edge detector should not identify multiple edge pixels where only a single edge exists (Response).

The first step in this edge detection consists in making a smoothing of the image to get out the noise which contaminates the image. So a two-dimensional Gaussain mask is created to be convolved with the image. The standard deviation of the Gaussian is a parameter set manually by the user.

The second step consists in computing the magnitude at each pixel of the smoothed image. The derivative filter is a one-dimensional mask convolved with the image in the lines' direction and in the columns' direction. Two images are obtained.

The third step concerns the "nonmaximum suppression". An edge is detected where the variation of grey-level is significant. The magnitude, which is the variation speed of the intensity for each pixel, will determine if a pixel will be selected or not to belong to the edge.



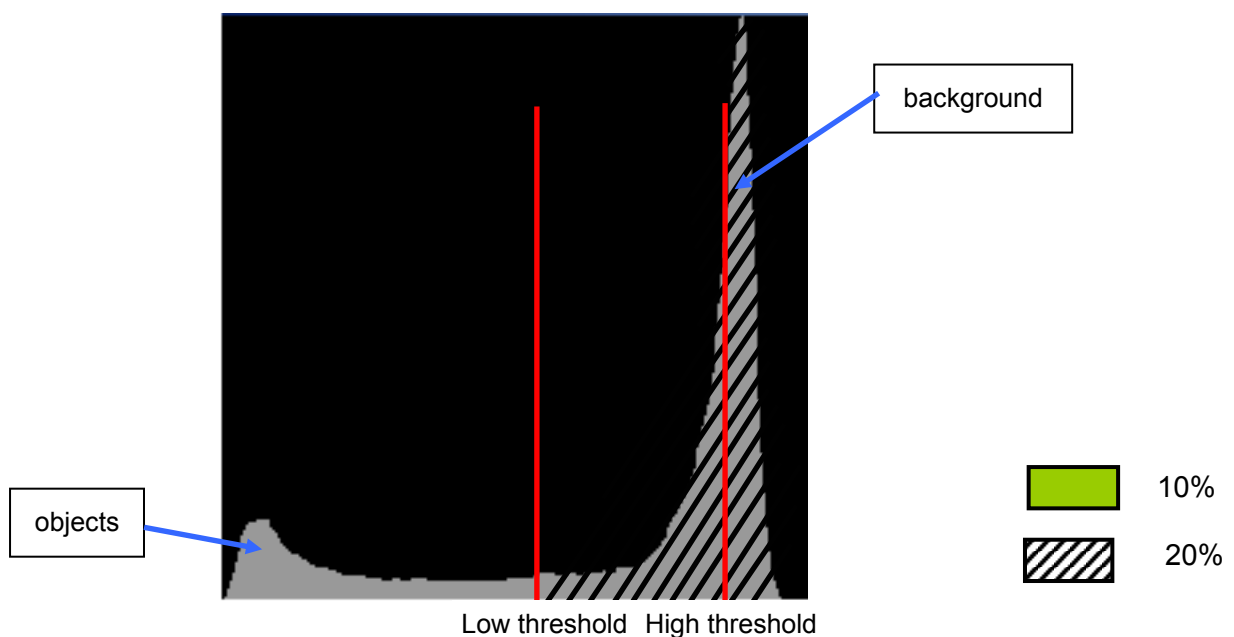
In this illustration, arrows represent the gradient direction for each pixel, and their size is proportional to the gradient magnitude.

Let's see the centred pixel. From this one, let's go in its gradient direction until finding another pixel. This last one is the first neighbor. Now let's do the same in the opposite direction to find the second neighbor. By going from one of the neighbors to the other one, we find an edge pixel so the gradient magnitude must be more important at the edge point.

In general, we are between two pixels. So the magnitude is estimated from the gradients of the neighboring pixels. It's assumed that the gradient is a linear function. Then the gradient can be approximated by a linear interpolation.

In the final step, we apply a threshold method called "hysteresis". It consists in computing a double threshold (a high and a low) and applying it to the image containing only the local maximum points. Every pixel whose grey-level is above the high threshold, is a starting-point and every pixel connected to this starting-point, whose grey-level is above the low threshold, belongs to the edge.

These two thresholds, a high and a low threshold, are automatically defined from the gradient modulus histogram distribution. Experimental results have shown that if the high threshold is lowered and the low threshold is increased, the filter will be more sensible to the grey-level variations. But it will be also more sensible to the noise.



## 2. QUADTREE STRUCTURE ALGORITHM

In a first time, the whole image is decomposed into four areas with the same size called quadrants or nodes. If one of this four quadrants contains information, the quadrant is subdivided in its turn, into four quadrants, otherwise, the quadrant is not subdivided and it becomes a terminal node.

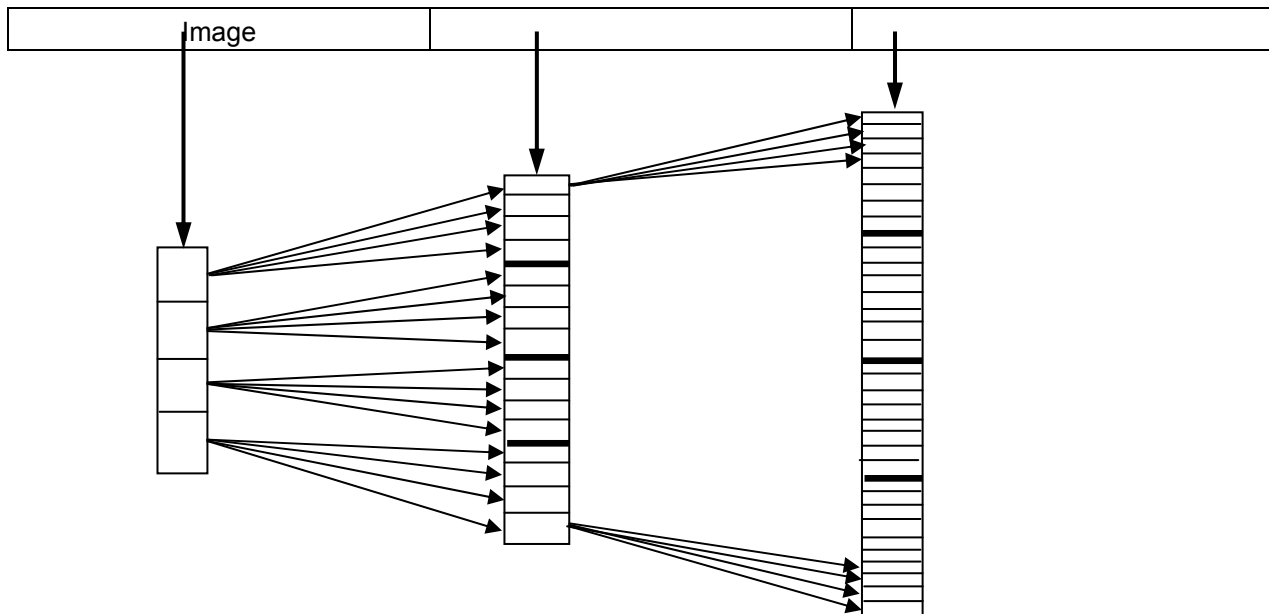
While the criteria of presence of edges in a quadrants is validate, the recursive decomposition is applied to this quadrant.

This recursive decomposition is represented in a tree data structure.

Once the decomposition is over, a threshold is computed for each terminal node. We start by the last level and we precede all the terminal nodes defined at this level. For those one which contain edge pixels, the threshold is an average of the grey-levels corresponding to the grey-levels of the pixels from the smoothed image.

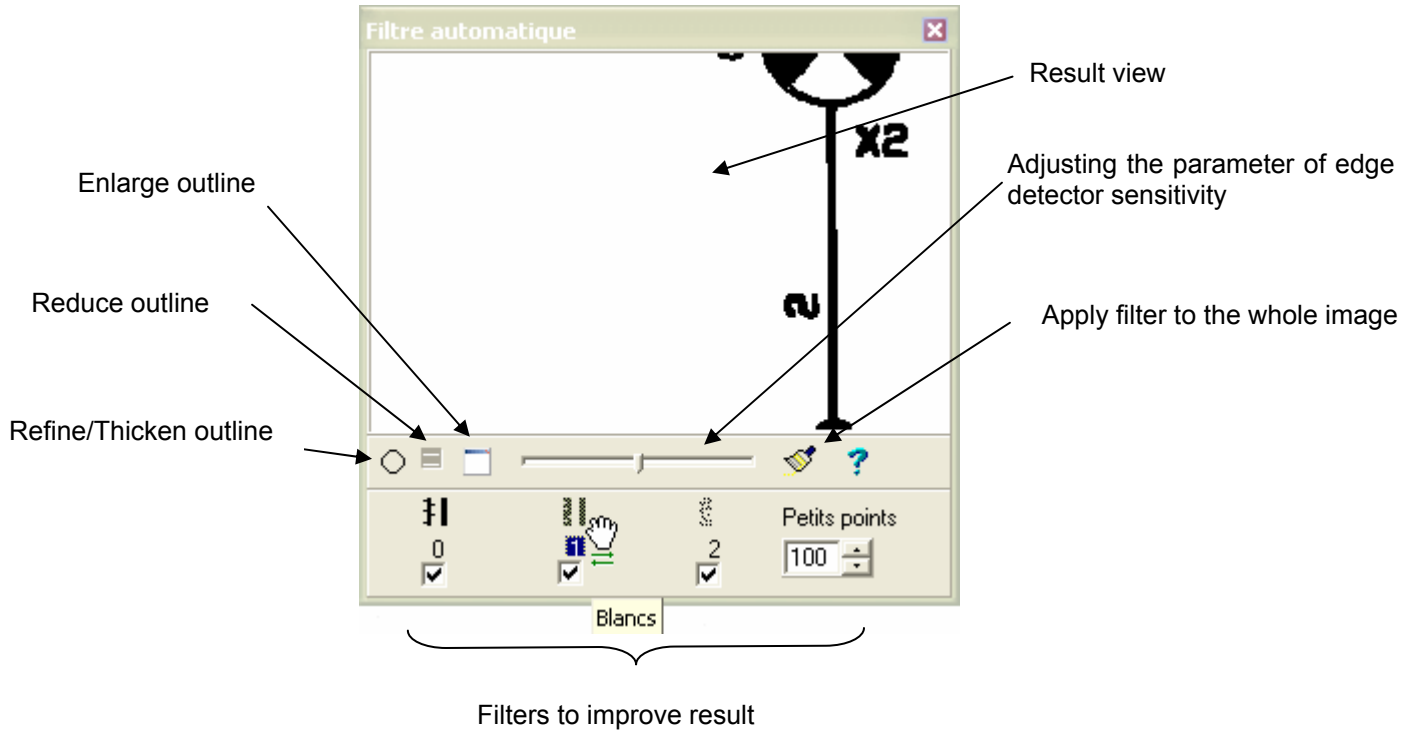
For the terminal nodes which do not contain any edges, the threshold is the average of the neighbours' areas thresholds containing edges, and belonging to the same level.

Then the whole image is binarized following the local threshold defined locally on each node.



Prototype tools:

As images can be from different size (A4, A3...) the processing time can be quite long. And the result can be different according to the adjustment of parameters. That's why the adjustment can't be done on the whole image. So before applying the binarizing filter to the whole image, we have done a little window which permits to choose the best value for the different parameters whithout making the computation on the whole image but just on a part of it.



The order in which filters are applied can give different results. That's why we have given the possibility of changing their order. The position of a filter in the list view indicates in which order it will be applied. The order can be changed by a drag and drop of the little image representing the filter.