Project Number:	FP6-516059
Document number:	DR_FRESH_WP2_1_1
Document Title:	Deliverable report
Document status:	Final
Date:	14/02/07
Availability:	Confidential
Authors:	Algo'Tech Informatique

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

Keyword List WP2, image thresholding

SUMMARY

1. INTRODUCTION

Before analysing and processing a document, it must be converted in a binary image (image in black and white). An image in grey-level is obtained by the scanerisation. So, several processes must be done first, to convert the grey-level document in black and white. It's about cleaning and thresholding the image.

Segmentation of grey-level images consists in making a partition of the image into several homogeneous regions.

Binarization is a particular case of segmentation. In image processing, binarization's aim consists in making two regions, one made by objects and another one made by the background.

There are several works made on image filtering.

- methods based on grey-level of regions,
- methods based on edge detection,
- methods based on thresholds computed for different regions.

Most of methods are either based on global or local threshold:

- In global approaches a threshold is calculated and applied to all the pixels of the image. Most of these methods use statistical methods like Bayes classifier or maximum likelihood, moment preservation, signal processing, Hadamard transform and multi-scale histogram separation.
- For some applications, local approaches are more accurate. Local methods use different thresholds according to the region under consideration.

The approaches proposed in document processing are based on features computed in predefine neighborhoods of points. So it's difficult to deal with little and high connexed components.

Furthermore, binarized documents can be of different qualities. The nature of the support and the degradation of documents influence the quality of the documents. Images to binarized are not homogeneous and have heterogeneous components. That's why a simple threshold won't give systematically good results.

So the aim is to find a filter wich would permit to suit a wide range of documents and which would not depend on the quality and the nature of the support, and whithout parameter.

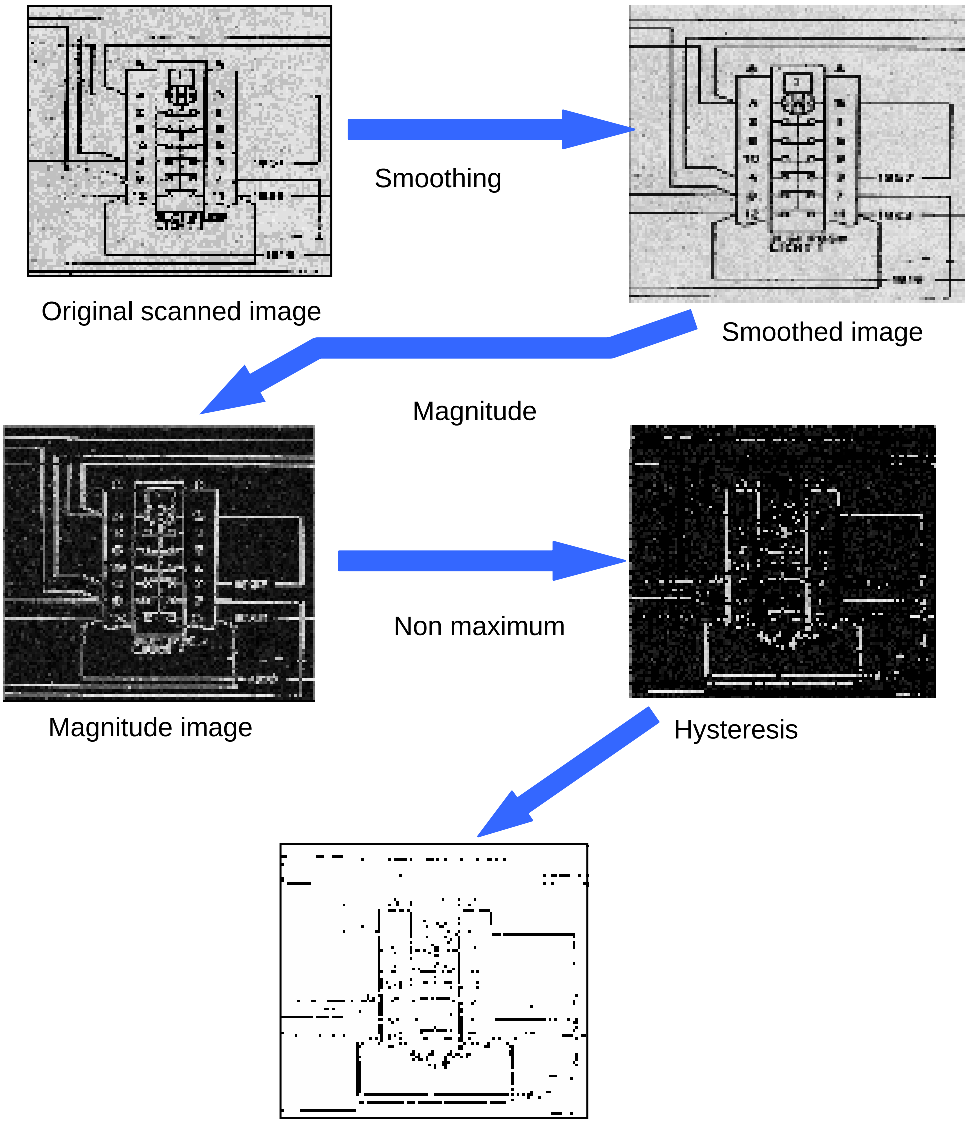
The method proposed consists in combining a global and a local approache. The approach is based on edge detection in the image to localize information and then is made a local threshold around edges detected.

In a black and white image, there is two regions, one made by the information and the other one by the background. We know that making a simple threshold will not systematically give good results. That's why our idea is to isolate the information to work in the neighborhood of it, in detecting edges of the image and in working near them.

2. EDGE DETECTION

Edges reseach in a numeric image is one of the most studied problems since the first works in numeric imaging. This is mainly due to the very intuitive nature of edge which appears naturul like the ideal visual clue in the largest cases.

2.1. CANNY EDGE DETECTOR



Edges image

The first step in image processing consists in making a smoothing of the image to decrease indeed remove the electronic noise due to the system of acquisition or to the quality of the support which contaminates the image. For this, we use a gaussian filter. This one has the best compromise between spatial and frequential localisation.

So we create a gaussian mask in two dimensions which is convolved with the image.
The size of the mask is difficult to choose because it has an effect on different points that we have to take under consideration. So a compromise must be found taking care about the result expected. That's why we have choosen a mask about 5*5.

The second step consists in computing the magnitude of each pixel. For it, a derivative mask is calculated The derivative filter is a one dimensional filer convolved with the smoothed image in the row direction and in the column.

The third step consists in computing thresholds for hysteresis. To make the hysteresis a high threshold and a low threshold are necessary. Two percentages are fixed by the user. Generally these percentages are 90% (high threshold) and 80% (low threshold) or 80% and 70%. The grey-level above whome there is 90% (respectively 80%) of the pixels on the magnitude histogram corresponds to the high threshold (respectively to the low threshold).

The fourth step is non maximum suppression. An edge is a significative location of grey-level variation. The gradient of a pixel is characterized by its magnitude; it represents the speed of intensity variation. With the magnitude of each pixel, we make a selection of pixels whose grey-level variation is enough to belong to edges. The pixel under consideration must have a larger gradient magnitude than its neighbors on the gradient direction

The fifth step is a thresholding step called “hysteresis” which uses two thresholds, a high and a low one. Each pixel whose grey-level is higher than the high threshold is a starting point and every pixel connected to this starting point with a grey-level higher than the low-level belongs to edges.
If some pixels with a high grey-level are not connected to a starting point, they will not be taken under consideration. That’s why we have set up a third threshold. We start from a pixel with a grey-level higher than the high threshold. And then all the pixels connected to the starting point with a threshold higher than the third threshold are selected. Then, starting from the terminal pixels, we go up until we find a pixel with a grey-level higher than the low threshold.

2.2. OBJECTS

At this stage we have an image of edges. In a first time we tried to enclose edges, because when it’s done, it’s very easy to binarize the document, every pixel located in the edge makes part of the objects whereas pixels which are out of the edges belong to the background.

3. QUADTREE STRUCTURE

Edges are the place of interesting information. On one side of the edge pixels belong to the information and on the other side they belong to the bakground. That’s why it’s important to work locally, near edges
After some experimental tests, it appears to be very difficult to describe a textured area with an enclosed contour. So we continue to work with edges but whithout trying to enclose them. We make a local thresholding around edges.
The idea is to compute local thresholds in edges’ neighborhoods, which are distributed at the rest of the image in areas which don’t contain edges that’s to say areas whithout any information to be thresholed.

So we have to find a method of decomposition of image which permits to isolate areas containing edges from empty areas which don’t give any information.

3.1. PRINCIPLE

The quadtree is a representation of the image whose root is the whole image. Its aim consists in dividing the image in n aparted areas whose joining is the whole image.

This tree data structure permits to make every type of region segmentation of an image. That’s why this structure seems to be suitable to the segmentation of edges image.

First, we provide the edges of the image, and next, from the edges we make a quadtree decomposition of the edges image. On each area of the image, a local threshold is computed and applied to all the pixels belonging to the region under consideration.

In a first time, the whole image is decomposed into four areas with the same size called quadrants or nodes.
While the criteria of presence of edges in a quadrant is validate, the recursive decomposition is applied to this quadrant. And the size of the region must be greater than a threshold to avoid to small regions containing only few pixels.

Once the decomposition is over, a threshold is computed for each terminal node. We start by the last level and we proceed 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. If the grey-level of a pixel from the smoothed image is above the threshold of its corresponding area, the pixel belongs to the objects else it belongs to the background.

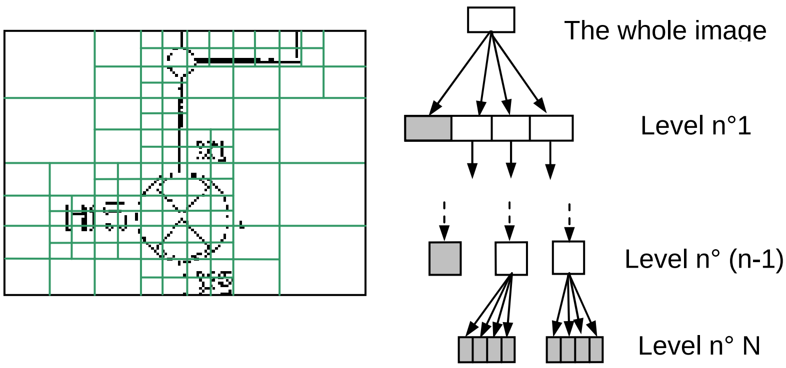
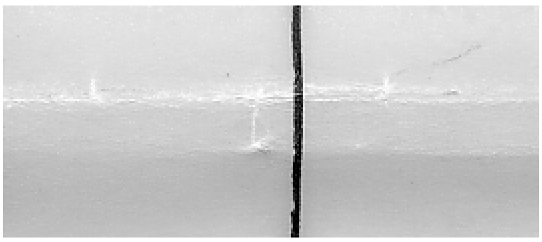


Fig. 1. Example of quadtree result for an edges image

As we say in introduction some times on tracing paper, there are some bends. They make some white lines on the support.



Bends provoke the detection of edges.But it's specific of tracing paper edges are reversed because bends are brighter than background.

So when we compute the threshold on an area with bends, and binarize this area, the bakground is put in white and pixels corresponding to the bend are put in white. So we have to test after binarization each area.