SOME NEW GLOBAL PARAMETERS TO QUALIFY THE HANDWRITING

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Abstract

This paper takes place in the field of handwriting analysis. More precisely, our aim is to extract some information from the writing image itself. An OCR could improve its recognition rate from this information. We are concerned with 300 dpi off line text, and are working on the binary images of the text lines. We are establishing the definition of some new parameters that rely on the evolution of line profiles when changing observation scale. We show how these parameters can quantify such properties of handwritten texts as the degree of loops on stroke or the average leaning, for example. Also, some experiments have been pursued on printed texts in order to have a reference.

Introduction

Nowadays each scanner is working together with an OCR software; nevertheless, it has to be observed that in nearly all the recognition methods, an analysis of the writing is only very superficially performed. The goal of our study is to discover new parameters that would enable the improvement of the recognition step by use of a pre-clustering of the writings according to the writing style.

In fact, when applying fractal tools to the study of writing profiles, we are going to show in this paper that it is possible to find, out of the written information, some criteria relying on global geometrical singularities, on legibility and on the importance of the details. More over, when used under some conditions, this tool can give way to the size of the writing. Besides, this study shows that it is possible to get a measure of the degree of loops on strokes. In the same way, the global leaning of a hand-written sentence is been reached.

After the measurement principle is explained, we precise the parameters that have been introduced. Then we present the discrimination results it has been possible to achieve.

1 Recall on fractal geometry

1.1 Definition of a rectificable curve

If $\Gamma(p)$ is a curve (figure 1.1), it can be approached as the union of all straight line segments $\eta(p)$. A measurement of its length is reached by the summation of the measures of elementary length of the segments : $\eta(p)$. The segments and their length will be both denoted by $\eta(p)$.

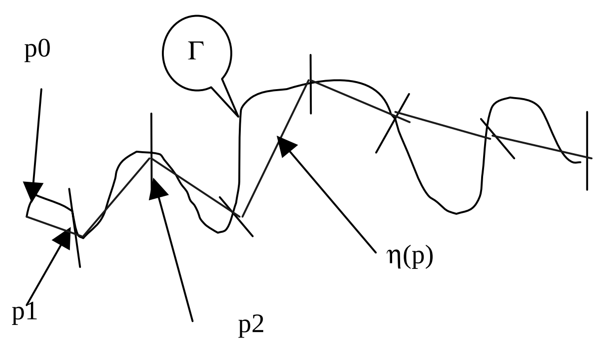


Figure 1.1 : rectificable curve.

The curve is rectificable, if a limit of the measure exists when unit scale becomes small. This measurement is the most accurate as the number of straight segments is higher and their length is smaller. This is why it is called by the geometrician the surveyor method.

So it is allowed to write under this hypothesis that the length λ(p) of the curve Γ(p) is defined by :

$$\boxed{\lambda(p) = \lim_{\substack{N(p)\longrightarrow\infty \\ \eta(p)\longrightarrow 0}} N(p).\eta(p)}$$

Where $N(p)$ is the number of straight equal segments : η(p) which are of the same measurement length.

1.2 definition of a fractal curve

If Γ(p) is a “curve” without finite length and with homogeneity in its shape., then this mathematical object is called a fractal. If N(p) happens to be the inverse of a real power of η(p) (whose measure is l_0), the relation that Mandelbrot has given, holds :

$$\lambda(p) = \lim_{\substack{N(p)\to\infty \\ \eta(p)\to 0}} N(p).\eta(p) = \lim_{\eta(p)\to 0} \eta(p)^{-\Delta}.\eta(p)$$

$$\lambda(p) = \lim_{\eta(p)\to 0} \eta(p)^{1-\Delta} = \lim_{l_0\to 0} l_0^{\,1-\Delta}$$

In fact the measurement of a fractal curve appears to present a linear evolution with respect to a Log-Log graph (figure 1.2). Δ is the slope and is linked to the fractal dimension.

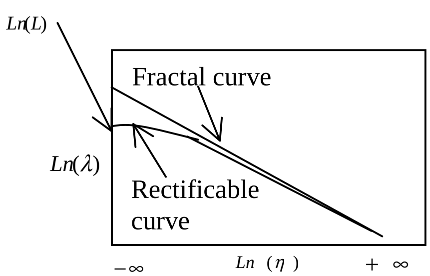


Figure 1.2 : fractal curve

This simple relation is generalised in an indepedent way according to the physical dimension of l_0 : if we talk about meter, λ(p) will be a length. If we talk about square-meter, λ(p) will be a surface, and so on...

1.3 a fractal example : the Von Koch curve

If we repeat step (a) then step (b) a large number of times : we obtain a fractal curve for which length has no means. A notice can be made because the curve shape presents some auto-similar properties (figure 1.3).

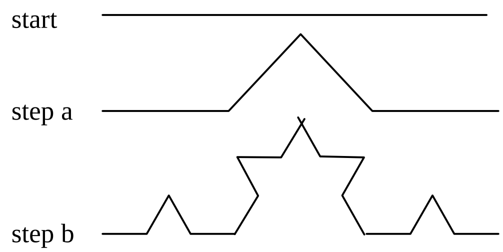


Figure 1.3 : No finite measure and auto-similarity of the curve shape

2 Measurement principle

2.1 Problem position

Till now, as far as writing was concerned, the fractal approaches [1] [2] [3] have been concerned with text images but the specific property of the text contained in the image has not been taken into account, more precisely, the structure of the text in lines has been ignored.

Nevertheless it is an essential point, a text shows this structure and any precise analysis of a writing must begin with the extraction of the text lines out of the image without any trial to understand the semantic contain of the text [4]. It is from the analysis of the shapes of the lines that we will be able to establish characteristic profiles that will give way to an interesting clustering [5] [6] .

For the construction of the profiles, we consider only the upper and lower profiles of the text line. Then the line is seen as the zone in between the two profiles [7] [8].

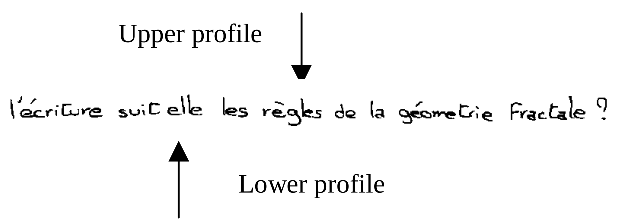
2.2 Profile extraction

The profiles are obtained as successive points; on each column only the top pixel and the bottom pixel, the upper and lower limits of the writing are considered. This data is the most precise we can derive from the image analysis. To make the precision vary, we have made use of a morphological operator.

For each column, we consider a vertical band with fixed width, then, the hand-written line is between the extreme text points the vertical band can approach without touching the text, either from above or from underneath. We have chosen an overlapping mask, so that invariance of the result towards translation is realised.

The bands are shifted from column to column and the ordinate of the extreme points are affected to the left column (figure 2.1 (a)). The smaller the width of the band is, the more accurate the outline of the text will be.

By this way, for a 1 pixel band width , we get the exact outline of the text zone and we model a vision close to the text (figure 2.1 (b)). On the other way, a 300 pixels band width, for example, will model a far vision (figure 2.1 (c)).



(a): measurement principle

(b) 1 pixel band width

(c) 300 pixels band width

Figures 2.1 : two different areas for two band widths ((b) 1 pixel on top, (c) 300 pixels under).

So, we have a way to observe the quantitative evolution of the text zone. We can compute the area of the zone between the two profiles, calculated with respect to the width of the band that is considered. The evolution of the areas is presented as the decimal logarithm of the normalised ratio to the first one.

On figure 2.2, we show an evolution graph associated with a written text. Then we are ready to define new parameters.

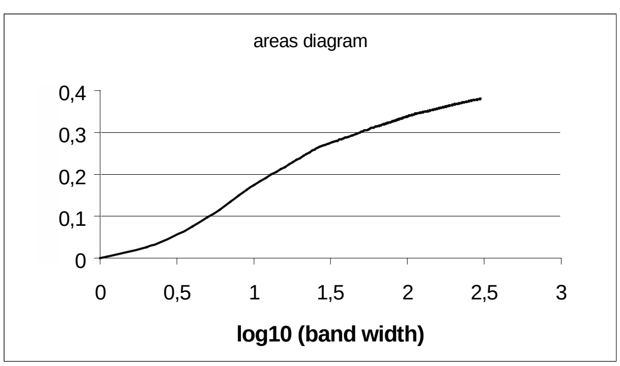


Figure 2.2 : areas diagram.

3 Some new parameters

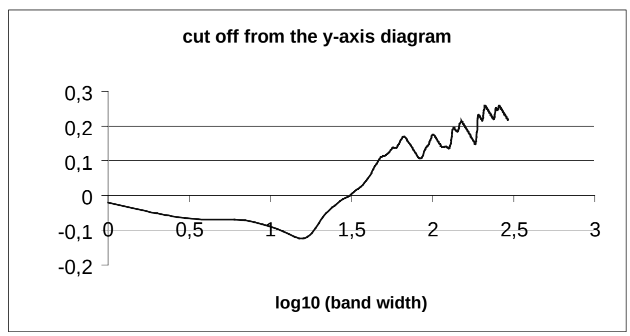
In order to extract more easily some significant parameters and to interpret them, we have visualised the evolution of the area on a graph where the logarithm of the areas is shown according to the logarithm of the width of the band used to define the text line zone.

A first rapid look at the graph makes apparent that globally the points are quite well aligned.

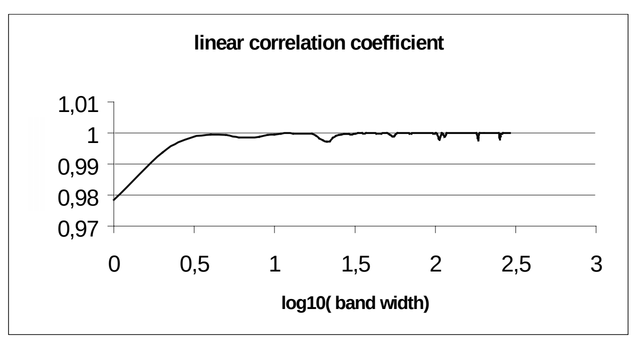
To improve our study, we have computed a linear regression calculus using nine consecutive points from the previous graph, within a mobile window.

The regression straight lines that are obtained are characterised by their slope, their cut off from the y-axis, and the linear correlation coefficient computed with the 9 points.

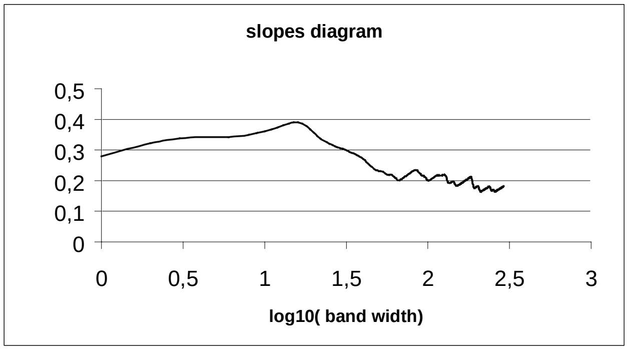
These variables allow the definition of 3 graphs with respect to the width of the band concerned.



(a) cut-off from the y-axis



(b) linear correlation coefficient



(c) slopes diagram

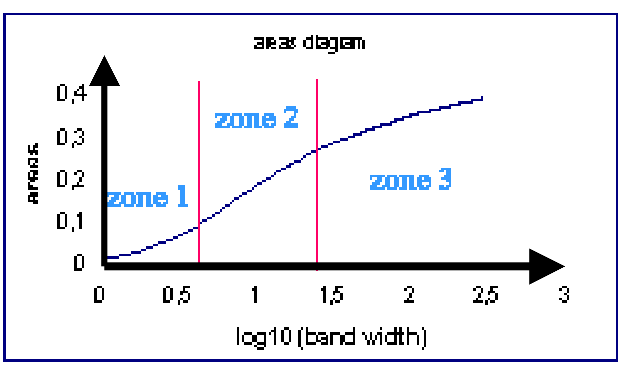
Figures 3.1 : (a), (b), and (c) are three evolution graphs associated with a writing.

Other parameters concerning the writing could be defined such as :

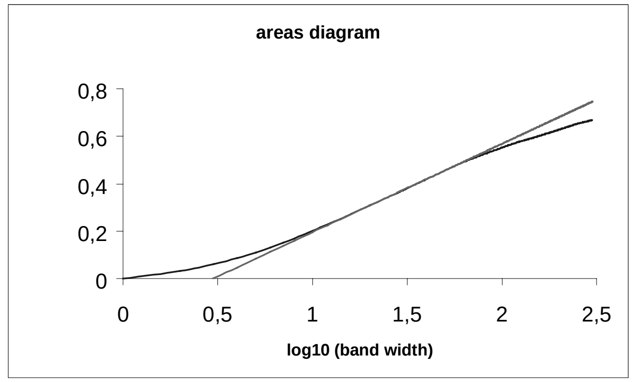
- the position and the amplitude of the least correlation peak,
- the position and minimum of correlation,
- the maximum of the slopes in the slopes diagram,
- the maximum and minimum of the cut off on y-axis,
- the slope defined by the first two points on the correlation graph.

Nevertheless, in order to improve the discrimination power of the parameters we define, a principle component analysis has been achieved, so we have decided to limit the final definitions to the first three parameters we are to define as follows.

- **GGS** (Global Geometrical Singularities) is the slope defined from the set of all the points of the zone 2 in the area graph (figure 3.2);



(a) three zones of fractality



(b) linear regression in zone 2

Figure 3.2 : (a) and (b) computation of GGS in zone 2 of areas diagram.

- **BGS** (Best Geometrical Singularities), is linked to the best focus of attention zone for the human eye, its value is the maximum value of the slope graph (figure3.3);

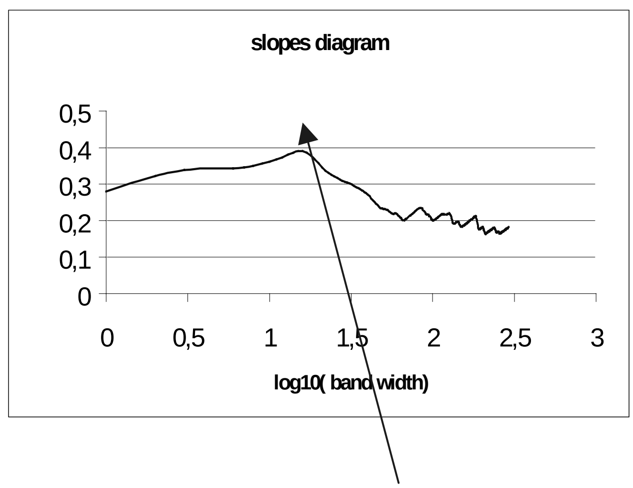


Figure 3.3 : BGS localisation.

- **DGS** (Detail Geometrical Singularities) is a statistical parameter concerned by very local behaviour, it is defined as the slope of the line defined by the first two points of the correlation graph (figure 3.4).

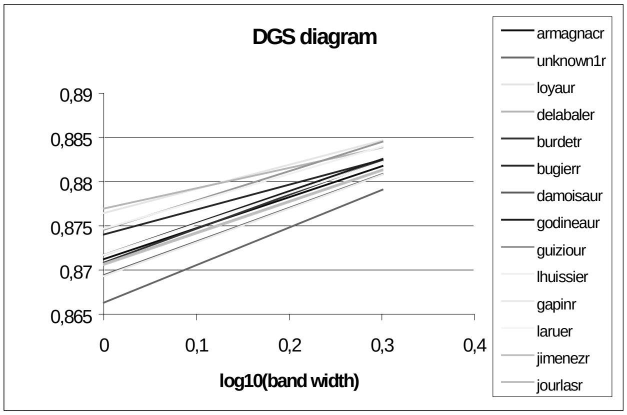


Figure 3.4 : DGS for different handwritings.

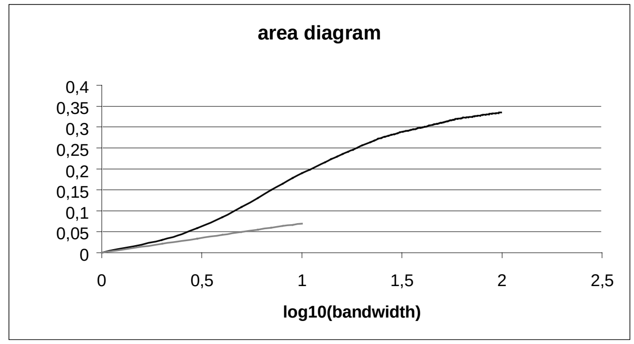
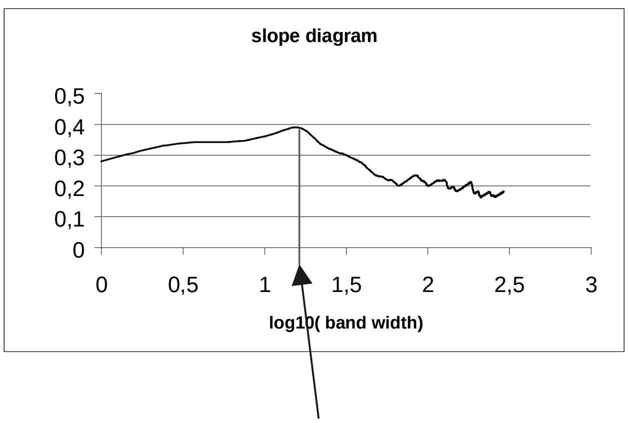


Figure 3.6 : computation of GLD as the slope in zone 1 of area diagram.

- **LDS** (Loop Detection on Stroke) is computed by the use of the regression straight lines that are obtained and characterised by their slope. This variable allows the definition of graph 3.5 with respect to the width of the band concerned.



Figures 3.5 : evolution graph associated with the slopes LDS localisation.

At this point a new parameter can be defined. The loop detection on strokes, **LDS,** is defined as the x-coordinate of the maximum in the slope diagram (figure 3.1).

- **GLD** (Global Leaning Detection) is another new parameter taking place and which is named the Global Leaning Detection. This value is the slope defined from the set of all the points of the zone 1 in the area graph (figure 3.6);

4 Results

Our fractal approach has shown a behaviour of the writing image that can be qualified as a multifractal behaviour because of the three zones in the areas diagram (figure 4.2).

To verify the reliability of our method we have applied the method to different resolution images, from 100 dpi to 300 dpi. Of course, the interpretation of the obtained results vary according to the goals that have been fixed.

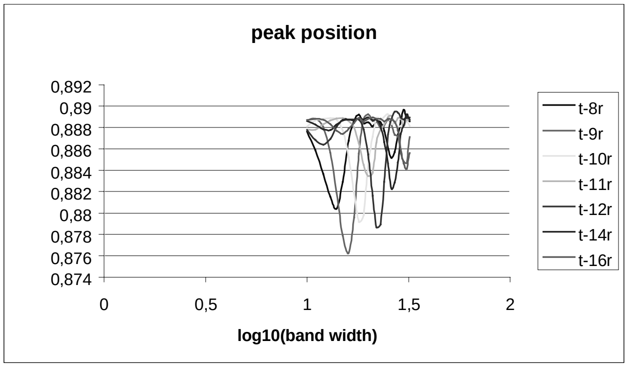
A 100 dpi resolution makes possible an estimation of the height of the text. Besides with a 300 dpi resolution, it has been shown the measured values are independent from the semantic contain of the text. So the use of the five parameters is justified.

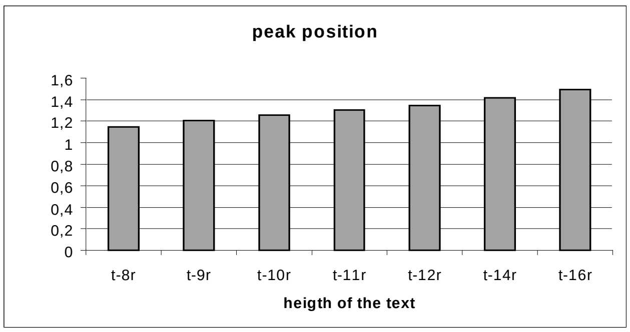
4.1 100 dpi approach

With this resolution, the spatial occupation of the text is not enough in order to get significant results from the three new parameters [9] [10]. It is only when resolution raised to 200 dpi that the parameters get some signification.

This remark shows that the behaviour of our morphologic tool is in accordance with the studies on fractal measurement tools.

However, if printed texts are studied and according to the linear correlation graph, it can be shown that the least correlation peak is able to quantify the height of the text depending on its position on the x-axis (figures 4.1). Of course this application on printed text is only a reference that will make possible future comparison with handwritten texts.





Figures 4.1 : measurement of text height.

4.2 300 dpi approach

GGS parameter can be used to quantify a global regularity of the written lines, so discrimination between written texts according to their regularity can be achieved and it allows for instance to oppose printed text behaviour to hand-written text behaviour.

So, on the one hand, a value near 0 will traduce a printed like and less cursive handwriting. On the other hand, a far value from 0 will show a most regular cursive handwriting. (figures 4.2, 4.3, 4.4).

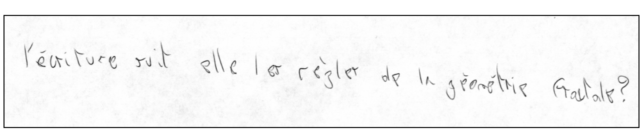


Figure 4.2 : a very printed like and less cursive handwriting : not a good legibility.

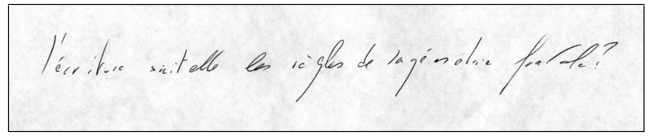


Figure 4.3 : a more cursive handwriting : a better legibility.

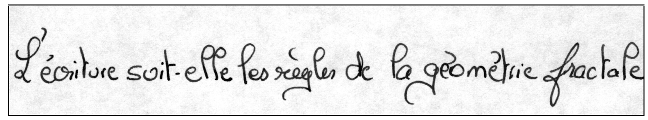


Figure 4.4 : cursive handwriting with a good legibility.

Besides, parameter **BGS** is more linked to "legibility" of the text, in the sense that extraction of the details in the writing is easier and that the global perception of the text is precise enough without too much difficulty (figures 4.2, 4.3, 4.4).

Graph of the figure 4.5 shows all of this. It is interesting to notice the localisation of four different printed sets : times, script, arial and courier.

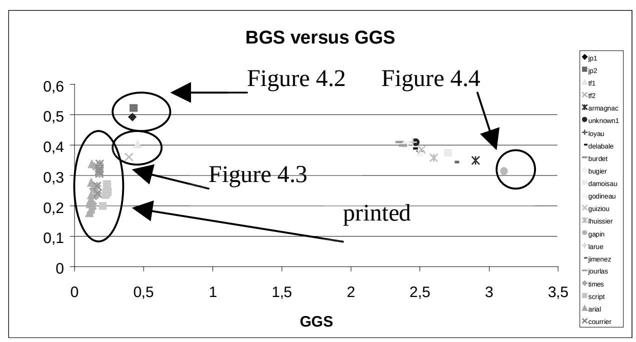


Figure 4.5 : BGS versus GGS.

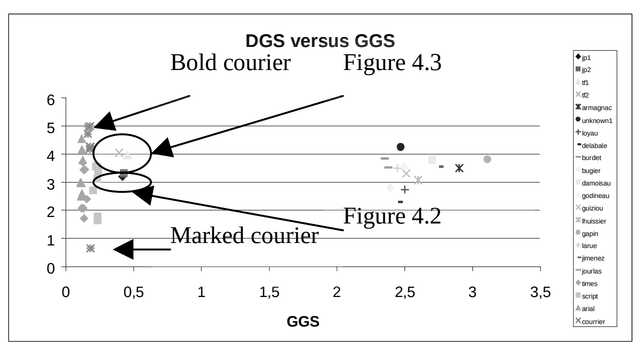


Figure 4.6 : DGS versus GGS.

The parameter, **DGS**, makes possible a characterisation of the details that are more or less visible in a global perception, (figure 4.6) according to the values of the points which are more or less far away from 0.

An example is given by the graphs 4.7 ((a) bold courier and (b) marked courier) and the graph 4.6 shows the resulting values for DGS. Too, it is interesting to note the position of the three previous writings.

(a) : **L'écrit**

(b) : L'écrit

Figure 4.7 : (a) : bold courier (b) : marked courier

The **LDS** parameter detects the presence of straight lines or curved lines on strokes of the writing. A sample is given to ilustrate this fact on figures 4.8, 4.9 and 4.10. A comparison between the different values of LDS is shown on figure 4.11

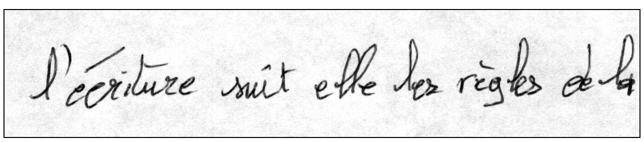


Figure 4.8 : a writing with straight lines and curved lines on the strokes.

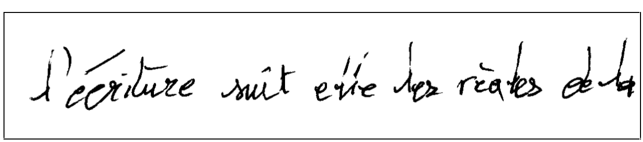


Figure 4.9 : a writing with only straight lines on the strokes.

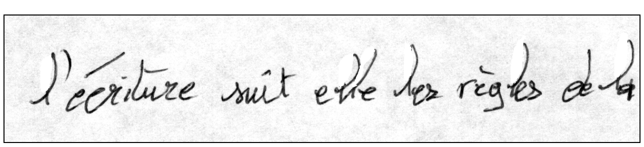


Figure 4.10 : a writing with only curved lines on the strokes.

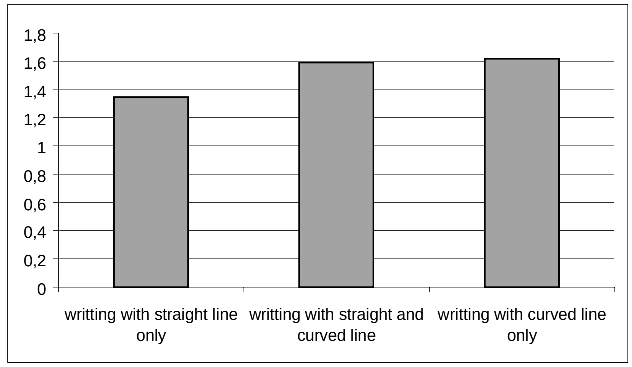


Figure 4.11 : comparison between the values of LDS

For the **GLD** parameter, the representation of the writings is combined in our database in a 2D representation space (GLD,LDS) and makes evident two principal families on the y-axis according to the fact that loops on strokes are present or not.

On the other hand when a point is close to the y-axis, it can be deduce that the leaning is important (figure 4.16).

Figures 4.12, 4.13, 4.14 and 4.15 are placed in this 2D space (figure 4.16).

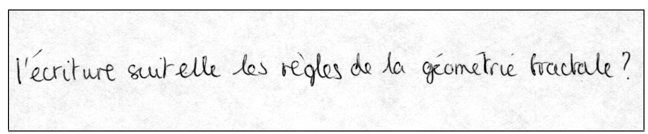


Figure 4.12 : straight handwriting without loops.

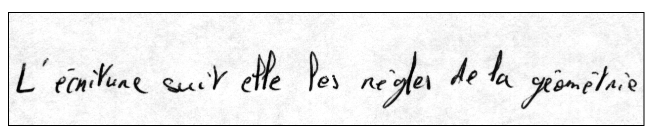


Figure 4.13 : straight handwriting with loops.

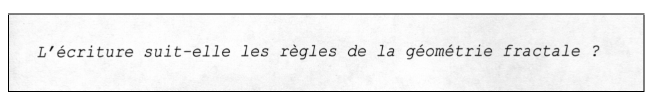


Figure 4.14 : forward sloping writing without loops.

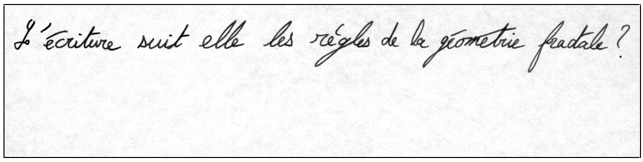


Figure 4.15 : forward sloping handwriting with loops.

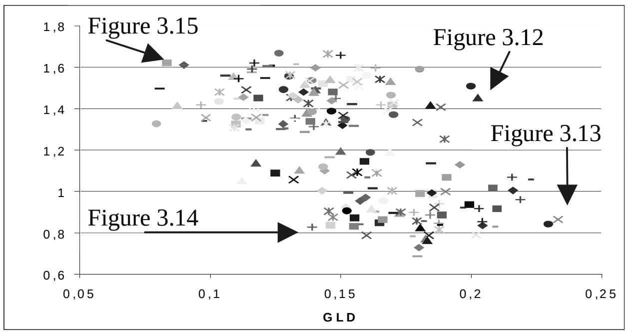


Figure 4.16 : LDS versus GLD.

Conclusion

In this study, it has been possible to define, for 300 dpi text images, 5 new parameters that improve the information extracted from the writing itself.

Satisfactory results have been obtained as far as Latin writings are concerned. Now, our efforts are concentrating on the use of knowledge given by the analysis of grey level images,.

The first results are encouraging and all the methods performed to this point begin with the noisy background remove.

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