Ancient Graphic Documents Characterization

Uttama. Surapong, Mouhamed. Hammoud, Cedricq. Garrido, Patrick. Franco, Jean.Marc.Ogier

L3i Laboratory, University of La Rochelle, Pole Sciences et Technologies, Avenue Michel Crépeau
17042. La Rochelle, France
E-mail: jean-marc.ogier@univ-lr.fr

Abstract

This research falls under the will to preserve the cultural and scientific inheritance of a society in order to ensure the greatest number the access to this inheritance. In France a group of laboratories, gathered in what we call an ACI MADONNE (what stands for MAsse de DOnnées appliqués à la Numérisation du patrimoiNE), studies and works on the implementation of methods which will make it possible to carry out these objectives.

In this paoer, we present a new method of image's signature based on a principle of content based recognition. This signature is computed from a set a layers issuing a segmentation process. It allows to represent the spatial organization of the different catgories of information, what can be considered as a relevant signature in a content based retrieval system

Keywords: Graphics , Content Based Image Retrieval system, signature.

1 Presentation

This research falls under the will to preserve the cultural and scientific inheritance of a society in order to ensure the greatest number the access to this inheritance. In France a group of laboratories, gathered in what we call an ACI MADONNE (what stands for MAsse de DOnnées appliqués à la Numérisation du patrimoiNE), studies and works on the implementation of methods which will make it possible to carry out these objectives.

In this article, we will present, initially, a new method of image's signature based on a principle of content based recognition. In the second time we will see some ways of possible application of these results to reference lettrines in a database. The method suggested in this article is based on the extraction of a features vector computed thanks to the Minimum Spanning Tree algorithm. In our first works, this technique is applied to the lettrine characterization.

2 Lettrines description

Lettrines are graphical objects which contain a lot of information. A quick seeing of several lettrines shows different common points between all those (Figure 1 and Figure 2). For instance, each of them has a framework, a parallel groups of lines representing texture, a letter, and the rest, i.e. the illustration itself, which is generally composed of small curves.

In our context of Content Based Information Retrieval, the aim is to try to compute a feature vector allowing to recognize a lettrine, or a part of a lettrine.

Many works concerning lettrines can be found in the literature, from an historical point of view [1] [2]. However, from an image analysis dimension, the works concerning the analysis and the indexing of such "graphic objects" are very rare. In our context, our aim is to develop some Content Based Image Retrieval techniques.

The history allow us to learn that Lettrines are printed on documents using wood plug, and that the same plug may have been re-used on the document until the end of its printing, , sometimes the plug can be used for creating other documents. Wood is far from being a matter stable during its use, so it is not rare, when we search about similar lettrine in a various documents or between the first and the last page of the same document, to notice that the general shape of the plug changes by an increasing or a decreasing of the thickness of the features.

This point also raises an important problem, because the method will have to be sufficiently robust to extract the same signature from lettrines coming from the same plug but on different dates.

	
Figure 1	**Figure 2**

Figure 1 and 2 : examples of lettrines

3 Segmentation of lettrines

In this paper, we focus on the characterization of lettrines, in order to permit to find a lettrine among a wide set of lettrines, for instance. Our processing strategy is based on a several stages, the first one of which is presented in another proposition of paper to this GREC workshop [4]. This first stage consists in segmenting the lettrine in different layers of information : different textures layers, uniform areas, ….

This operation is based on a strategy inspired from visual perception principles, that is summarized in Figure 3..

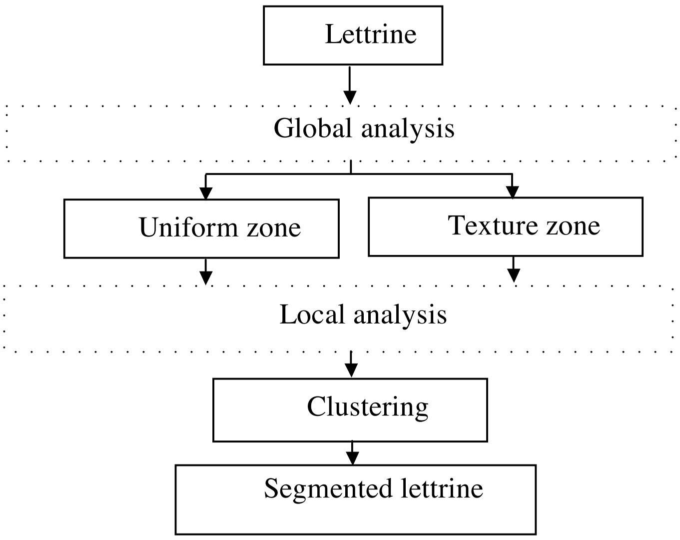


Figure 3 : General Scheme of a lettrine segmentation process

Actually, this segmentation stage is a first top-down technique, that will be followed by a bottom-up approach in our future works, in order to improve the quality of segmentation.

This segmentation process provides a set of layers characterizing respectively a category of information in the original image.

As a consequence, for instance, this stage can provide a layer corresponding to textures,, a layer corresponding to homogeneous areas, a layer corresponding to outlines.

Figures 4 and 5 illustrate an example of the homogeneous and textured areas computed from a lettrine image

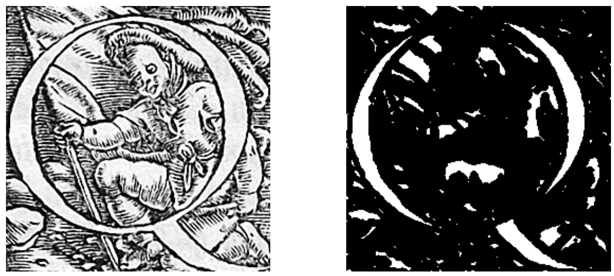


Figure 4. Original lettrine and its homogeneous areas

(a) (b)

Figure 6. Textured background extraction of rather simple lettrine

The details concerning the segmentation process that has been proposed been implemented is presented in another paper of the same workshop GREC 2005.

4 Lettrines characterization

Concerning the characterization of the lettrine, our idea is strongly inspired from keypoints or salient zones detection (Schmidt detector). Actually, we consider the spatial organization of the different layers of information extracted thanks to the segmentation stage as a good basis for the classification and the indexing approach.

In our context, at first, we experimented graphs for the description of the topology of the image and for the spatial organization description of the different layers. From this point, our current studies rely on the works presented in the previous GREC conference (GREC'2003), for which the topology of the image is based on the Minimum Spanning Tree Length.

Secondly, in order to compare with a relevant signature classically used in CBIR, and in order to reduce the complexity of the algorihm, we proposed to implement a signature representing the spatial relations of the regions issing from the segmentation process.

5 MST Based Signature

5.1 MST Decription

The MST is a structure derived from the graphs [3].

A graph G is defines as a unit made up of tops X, edges E, of an application f of E in the Cartesian product X*X, which for each arcs e of E associates f(e) representing a couple (xi, xj), respectively initial top and final top of the arc e. Finally V a whole of points associated each arcs e of E, with Card (e) = Card (V).

$$G : (X, E, f, V)$$

$$X = \{x1, x2, \dots, xn\}$$

$$E = \{e1, e2, ..., em\}$$

$$V = \{v1, v2, ..., vm]$$

$$f : E \rightarrow X*X$$

$$e \rightarrow (xi, xj)$$

Any related graph G (X, E, F, V) has several minimum spanning trees.

A covering tree is a tree G' of G, which containing each top of G but where there is only one and one way to go from a top xi, at a top xj, (xi, xj) □ X

$$G' : (X, E', f, V')$$

$$E' \varepsilon E$$

$$V' \varepsilon V$$

A MST is one of the covering trees of G' where the sum of the values of all its arcs e ε E' is minimum.

5.1 MST Based Signature

The first idea that we have had is to consider the MST as a quite relevant information for signing the spatial organization of a lettrine. However, MST do not apply any separation between the different layers of information that are present on the document. In order to avoid the confusion between these information, we tried to compute the MST on each of the layers issuing from the segmentation process, and considered the

MST Length as a signature of the layer. Doing like this, a features vectors integrating the MST length computed on each layer can be computed, and considered as a relevant signature of the lettrine.

In order to reduce the complexity of the MST computation, that is a quite costly operation, we applied the MST on each connected component of each layer, considering the gravity center as a relevant information (Figure 7).

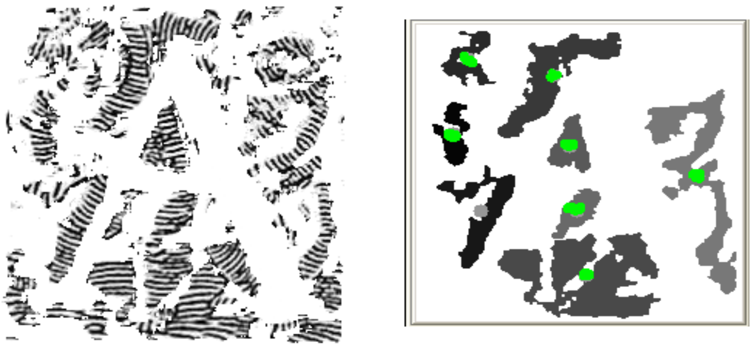


Figure 7 : Strategy of lettrine description

As a consequence, we computed the MST on each of these connected components, as shown in Figure 8

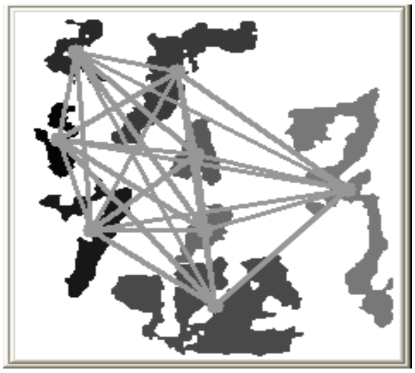


Figure 8 : Computation of the MST

The principle of this work is summarized in the following figure 7

Based on the computation of the Minimum Spanning Tree for each layer of information, we compute a features vector describing the spatial organization of the lettrine.

This technique allows to compute a feature vector, the size of which depends on the number of layers extracted from the lettrine (Figure 8)

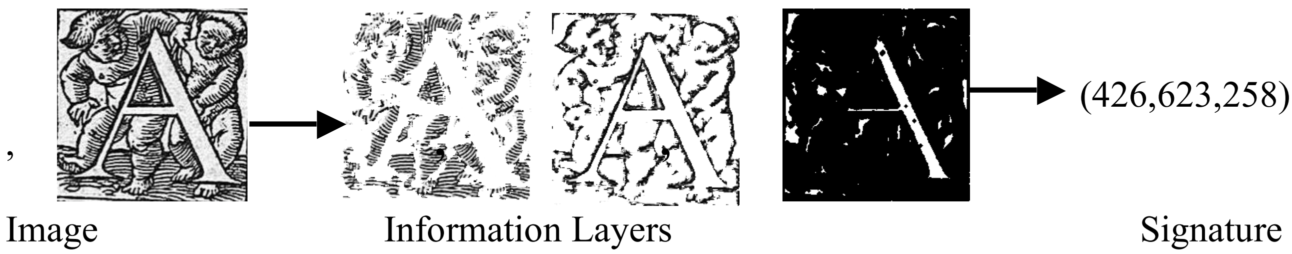


Figure 8 : Computation of the MST Based signature

5.2 Experimentation

This strategy of graphic image description is currently experimented on a wide set of lettrines that has been provided by one of our partner in the Madonne's project, by using a research engine (Figure 9).

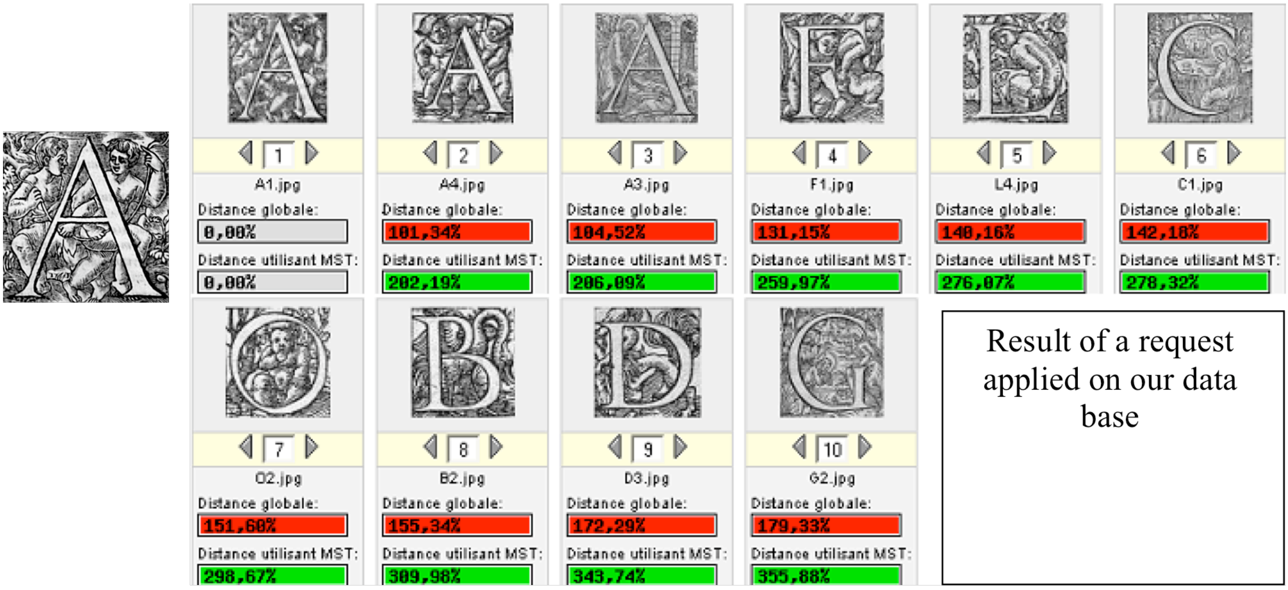


Figure 9 : Madonne Research engine

This strategy is currently evaluated in terms of recall/precision criterion. However, our first experimentation highlights the good quality of the retrieval process.

However, the computation of the MST is a quite expensive operation, and the MST Length computation is not a bijective operation that do not guarantee that it is the unique manner to describe an image. As a consequence, we deceide to experiment another approach, based on a relevant signature issuing from CBIR systems..

6 A New Signature

As said in the previous part, in order to manage the well known problem due to the non-bijective aspect of the MST leght computation, we have experimented a technique coming from CBIR system, proposed in 2003 by (Ref).

This approach takes as input the one as the MST Length strategy presented in the previous part.

The principle of this approach is to consider the relationships of each pair of connected components of the image, in terms of distance and orientation. In the original paper proposed by the authors, the input that were considered were vectors. In our case, the strategy that is applied is based on the connected components of each layer, and more specifically, on the principal inertia axis computed on each of them.

The different stages of the algorithm are the following ones :

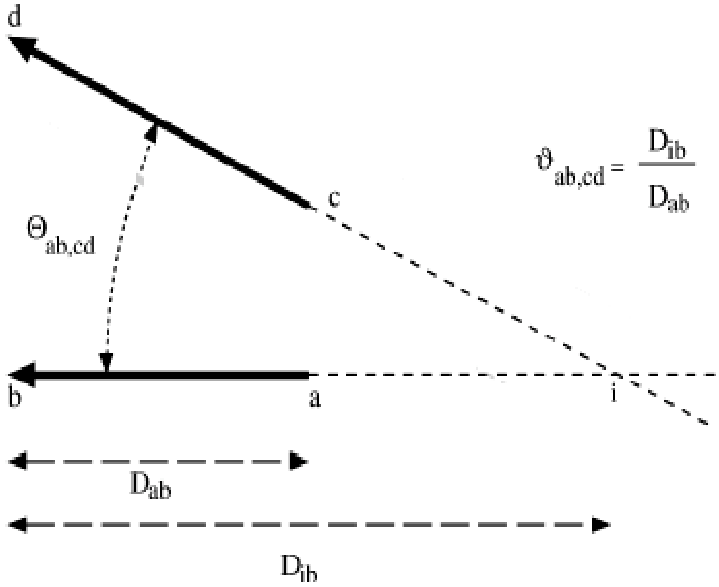
1/ Segmentation of the different layers (figure 10 a)

2/ Computation of the principal inertia axis on each connected component of each layer (figure 10 b)

(a) (b)

Figure 10 : Computation of the principal inertia axis on a segmented layer

3/ Computation of the relations between two principal inertia axis : Pairwise Geometric Attribute. This stage is the most “complicated one of the process, even if it is quite simple. For each pair of the principal inertia axis, it consists in computing a relation between them, in terms of angle and distance. More precisely, as shown in Figure 11, a computation of the angle and distance is operated between each principal inertia axis.



As a consequence, for each pair, we compute :

The angle between these two axis :

$$\alpha_{ab,cd} = \arccos\left[\frac{\underline{\mathbf{x}}_{ab} \cdot \underline{\mathbf{x}}_{cd}}{|\underline{\mathbf{x}}_{ab}||\underline{\mathbf{x}}_{cd}|}\right];$$

and the distance between them :

$$\vartheta_{ab,cd} = \frac{1}{\frac{1}{2} + \frac{D_{ib}}{D_{ab}}}.$$

4/ On the basis of the previous stage, computation of the histogram of relations : two-dimensional pairwise geometric histogram . Actually, this histogram represents the frequency of occurrence of relations between two similar situations :

$$H(I,J) = \begin{cases} H(I,J)+1 & \text{if } (i,j) \in E \text{ and } \alpha_{i,j} \in A_I \text{ and } \vartheta_{i,j} \in R_J \\ H(I,J) & \text{otherwise,} \end{cases}$$

where

E ={couples ($a_{i,j}$, $V_{i,j}$) i et j are two principal inertia axis }

A_I ={angles computed between two principal inertia axis }

R_J ={ratio computed between two principal inertia axis}

6.2 Experimentation

In terms of distance in order to measure the similarity between two images, at first, we used Bhattacharyya distance in order to compare two histograms.

This methodology is implemented in the research engine that we have developped in Madonne's project. The first results are encouraging, but highlight the problem of stability of the principal inertia axis, especially in terms of orientation. Some improvements are currently studied in our laboratory in order to improve the quality of the global process from this point. The results concerning these improvements will be given while the workshop. Our future works will go further in this research direction.

7 Conclusion

In this paper, we have presented our first results concerning lettrine characterization, in order to build a content based image retrieval system, in the context of ancient document valorization. This problem is integrated in a French research consortium, grouping several laboratories, and one historical center, who provided us the lettrines images.(Centre d'Etudes Supérieures de la Rennaissance de l'Université de Tours)

We defined two manners to characterize this graphical objects, on the basis of two complementary approaches. Both of these approcha take as input the result of a segmentation process, the principle of which is given in another paper presented at the Grec 2005 Conference [X].

The first one relies on the MST length

8 Acnowledgement

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