

# Retrieval of the ornaments from the Hand-Press Period: an overview

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**Abstract :** *This paper deals with the topic of the retrieval of document images focussed on a specific application : the ornaments of the Hand-Press period. It presents an overview as a result of the work and the discussions undertaken by a working group on this subject. The paper starts by giving a general view about the digital libraries of ornaments and the associated retrieval problematics. Next, main issues related to these problematics are discussed : image enhancement, block tracking, visual comparison and content based retrieval. Conclusions and open problems arising from this overview are at last discussed at the end of the paper.*

**Keywords :** ornament, retrieval, tracking, comparison, visualization, content-based

## 1 Introduction

This article deals with the topic of the retrieval of document images. During the last 25 year many works have been done on this field concerning official forms, maps, drawings, correspondences, etc. We focus here on a new application : the retrieval of ornaments from the Hand-Press period. This period runs from around 1454 (approximate date of Gutenberg's invention) to through the first half of the nineteenth century (when mechanized presses start to appear). The particularity of this period is the use of block of wood, with a relief carving on it, to print the ornaments of the books. Some examples of such ornaments are presented in Fig. 1.

With the growing of interest in the cultural heritage preservation in the 1990s, numerous works of digitization of historical collections have been carried out. Nowadays, large databases of ornaments of the hand-press period are available (see Tab. 1) and will still grow in the future. These ornaments are extracted from the whole digitized pages, using full automatic [UTT 05b] [JOU 07] or user-driven [RAM 07] segmentation methods, or recorded independently. The key problem is now to make available these images for research to specialist historians and for general users (like the artists, the designers, the publishers, the printers, the students, etc.). All of these constituencies have different needs which requires varied and sophisticated means of searching and accessing the information.



FIG. 1 – (from left-right and top-down) decorated initial, printing-house trademark, heraldry, emblem, picture, fleuron

Name	size	main type	period
HERON <sup>†</sup>	32 000	heraldry	18°
BVH <sup>‡</sup>	10 000	initials, emblems	16°
Passe-Partout <sup>**</sup>	4 000	fleurons, headlines	16-18°

TAB. 1 – Databases of ornaments

The general users expect web retrieval systems. They want to retrieve ornaments using text queries but also content-based ones to access the items, the textures, the colors, etc. Example of such an information system is the Hermitage Museum<sup>1</sup> : it allows text and content-based queries to retrieve pictures according metadata, color distribution and layouts. The specialist historians have different needs. They want to record the individual instances of ornament occurrence in order to identify the individual blocks. Once the blocks identified, they constitute thesaurus using subject-specific classification system (like Iconclass<sup>2</sup>) to describe the blocks. In both cases, automatic retrieval systems will help a lot to access the ornament databases. The development of such systems is a challenging task for the Document Image Analysis community due to different key problems :

<sup>†</sup><http://www.informatik.uni-augsburg.de/heron/>

<sup>‡</sup>Bibliothèques Virtuelles Humanistes <http://www.bvh.univ-tours.fr>

<sup>\*\*</sup><http://www2.unil.ch/BCUTodai/app/>

<sup>1</sup><http://www.hermitagemuseum.org/>

<sup>2</sup><http://www.iconclass.nl/>

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- image degradations (old age, lossless compression)
- scaling invariance (different scanning resolutions)
- complexity (masses of data)
- scalability (high number of block class)

In the last 10 years several works have been proposed on this topic. An overview can be found in [PAR 06a] but dedicated to a specific collection of methods (i.e. developed during a specific project and applied to a single corpus). This paper proposes a complete overview of the last 10 years' works at best of our knowledge. It reports too a summary of the discussions undertaken by a working group<sup>3</sup> composed both of historians and computer-science people. The rest of the paper is organized in four main sections (2, 3, 4 and 5) related to the main topics of ornament retrieval : image enhancement, block tracking, visual comparison and content based retrieval. **Comparison of methods, open problems and conclusions** arising from this overview are at last discussed in section 6.

## 2 Image Enhancement

The ornaments contain a lot of information concentrated in a small area. As a consequence, they suffer from global preprocessing algorithms used by the digitization platforms (skewing, cleaning, binarization, etc). These ones are applied on the whole pages without taking into their specificities. Other problems are the processes of automatic and manual segmentation. They introduce other defaults in the images like the shifting and the clipping. So, enhancement of ornament images is mandatory before applying any retrieval techniques. Up to date, only the system detailed in [NIC 08] has been proposed to do it. This one relies on two main steps illustrated Fig. 2 : registration (a) and cleaning (b). These steps are detailed below.



FIG. 2 – (a) registration (b) cleaning

The image registration step aims to geometrically align shifted images. The system proposed in [NIC 08] uses the method of Symmetric Phase-Only Matching Filter (SPOMF) to do it. The authors present this method as a very good way to register the ornament images in terms of translation, rotation and scale. The SPOMF originally works on translation registration only. In order to extend the registration to rotation and scale, they apply the SPOMF method on the Fourier Mellin Invariant (FMI) image. This combination FMI-SPOMF ensures the correct registration of two given images before any comparison.

The image cleaning removes next the noise in the ornament images. Among the existing methods, the authors have chosen one based on the Wavelet Transform. Wavelet Transform and multiresolution techniques allow to extract

two types of information from an original image : images of approximation and details. Fig. 3 shows an example of result obtained by the authors' system : a two-level wavelet analysis of a decorated initial. The approximation images contain mainly information about on the letter (D). The images of details describe local information such as the ornamental parts.

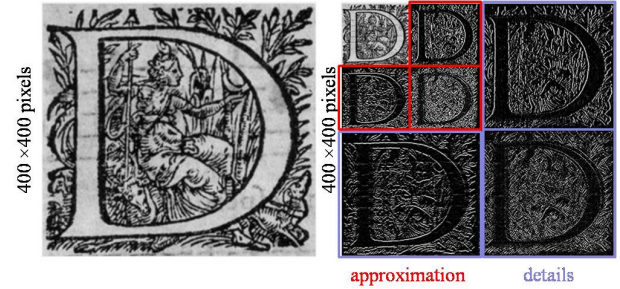


FIG. 3 – Two levels of multiresolution analysis

## 3 Block Tracking

In order to constitute a thesaurus, the initial work done by the historians is to record the individual instances of ornament occurrence and to identify the individual blocks. This identification work is also very useful to date the books and to authenticate outputs from some printing-houses and authors [COR 01]. Indeed, numerous editions published in the past centuries do not reveal on the title page their true origin. Fictive (London, by Bold Truth) or misleading addresses (Amsterdam, and on sale in Lausanne, by F. Grasset) are legion. To solve these problems the historians could rely on the analysis of the blocks to identify the typographic practices of printers. Indeed, these blocks could be re-used to print several books, be exchanged between the printing-houses or duplicated in the case of damage as illustrated Fig. 4. So, the reconstitution of the blocks could help to prove the book origins. We will refer here this task as block tracking. Because the block tracking is a long and complex work, four automatic systems have been proposed in the past to help the historians : [BIG 96], [CHE 03], [DEL 07] and [BAU 08].

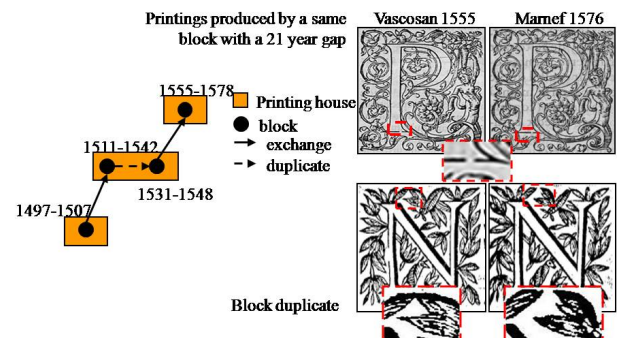


FIG. 4 – Block tracking

In [BIG 96] the authors propose a system for the retrieval of fleuron and headline images. Because the fleuron images are mainly composed of straight lines, the authors have chosen an approach based on the orientation radiograms. The

<sup>3</sup>See the acknowledgement section 7

Fig. 5 details their retrieval process. For each pixel of the image (a), a linear symmetry vector is computed. In geometrical terms, a linear symmetry vector corresponds to optimal straight-line fitted to the local power spectrum. The computed vectors are next used to build the orientation images with a  $\frac{\pi}{4}$  gap. The orientation radiograms (b) (c) (d) correspond then to the projection histograms of these images. These last ones are used to constitute the image signature compared together to obtain similarity distances between the images.

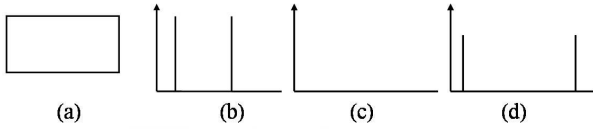


FIG. 5 – (a) image (b)(c)(d) radiogram 0°, 45°, 90°

The system of [CHE 03] is employed for the retrieval of emblem images. In order to reduce the usual time processing of such a comparison, the system works with interest points extracted from the images. The global retrieval process is then done in four steps. First the points of interest are extracted using a modified Harris detector. Next, from each of these points Zernike moments are computed. The mapping between the interest points of two images to compare is done using a  $5 \times 5$  template (e.g. if two templates overlap then the corresponding points map). The moments of the points are compared using a maximum likelihood estimation and a  $T$  threshold. The global score of similarity between two images is the number of fit points. The Fig. 6 gives an example of retrieval result (b) using the query (a).



FIG. 6 – (a) query image (b) 2<sup>sd</sup>, 4<sup>th</sup> and 6<sup>th</sup> results

The authors in [DEL 07] use an alternative approach. In order to make their system accurate and scalable, they compare the ornament images at a pixel level. However, in order to reduce the processing time required for such a comparison, they use a Run Length Encoding (RLE) of images as illustrated Fig. 7 (a). The experiments show a compression of 8 to 9 times of ornament images that therefore reduces the needed retrieval time. Fig. 7 (b) gives some examples of compression rates. The RLE are used in an image comparison algorithm in two steps : an image centering and then a distance computation. The centering step allows them to solve the shifting problems usually met between the segmented images.

In [BAU 08] the authors employ a more accurate approach using a local Hausdorff distance to retrieve images of emblems and illustrations. The process is in three steps applied to the request image and a database image : 1) a multiresolution that enables to choose a rough approximation adapted to the final user research criteria and reducing

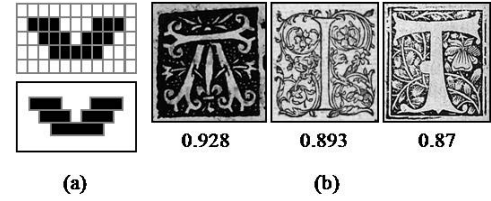


FIG. 7 – (a) RLE (b) Some compression rates

the computation time, 2) the computation of a local Hausdorff distance for each pixel resulting in a dissimilarity map, 3) a classification step using a SVM that gives a similarity score between the two images. Fig. 8 gives an example of computed dissimilarity map<sup>4</sup> (c) from the two images (a) (b).

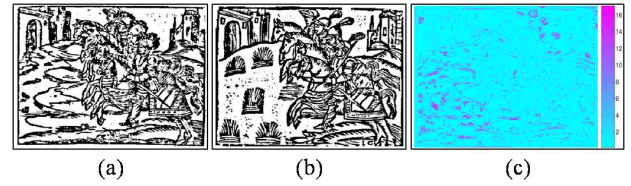


FIG. 8 – (a) image 1 (b) image 2 (c) dissimilarity map

## 4 Visual Comparison

Once the similar images have been retrieved (either automatically or manually), it can be difficult to notice visually the relevant differences between them. It is illustrated in the Fig. 9 : do the printings of the ornamental “A” come from the same block ? It is difficult to answer this question. However, the detection of these differences is useful for at least two tasks : to determine if two printings come from the same block and to make a relative dating between two printings coming from a same block.

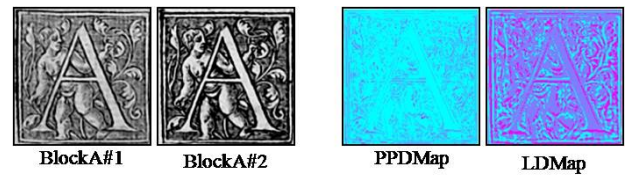


FIG. 9 – PPDmap and LDMMap of two block printings

The historians could be helped in these tasks with an automatic method of difference visualization. Up to date only the works of [BAU 07a] [BAU 07b] have been proposed on this topic. In their two papers the authors compare two visualization methods : the display of the map containing the pixel-to-pixel difference values (PPDMap) and the so-called Local dissimilarity Map (LDMMap). In order to assess these methods they make the following distinctions among the printing differences :

1. linked to the time degradations of paper pages.
2. done when using different digitization plate-forms.
3. done when using different pre-processing chains.

<sup>4</sup>The bright parts correspond to low distances.



4. resulting of the time degradation of blocks.
5. made by the engravers when reproducing the blocks.

Their methods aim to detect the differences  $\{4, 5\}$ , so-called pertinent differences, that interest the historians. The other ones  $\{1, 2, 3\}$  are then called perturbations. In [BAU 07a], a first test has been realized to evaluate the perturbation impact on the visualization methods. It shows that the PPDMap is very sensible to the perturbations and yields false alarms that hide the pertinent differences as illustrated Fig. 9. In [BAU 07b] also, another test evaluates the correlation between the dissimilarities values in the LDMap and an expert evaluation. It shows that the LDMap values do not reflect accurately the expert evaluation. But the visualization purpose is to show the user all the relevant differences in the images, even those that are not visually noticeable. In [BAU 07a], a signed version of the LDMap is used as visualization tool for the impression dating. This point is interesting but the printings should be very well registered so that the block ageing could perceptible.

## 5 Content based Retrieval

Because the databases of ornaments are now available on the web, not only the historian people could access them. General users (artists, designers, publishers, etc.) are interested in with different needs of historians. They expect web retrieval systems i.e. to retrieve ornaments using text and content-based queries (items, textures, colors, etc). Several automatic retrieval systems have been proposed recently to assist them in their researches : [KIE 98], [PAR 06b] and [UTT 05a].

The system described in [KIE 98] retrieves heraldic images using multi-features queries. These features describe mainly the shapes like the area circularity, the eccentricity, the major axis orientation and the algebraic moments. The Fig. 10 (a) gives an example of query result obtained when using these features. Additionally, the system employs texture detection and color segmentation methods to determine image tinctures and object positions. These attributes are used to compare restricted areas of the heraldic images. The textures are detected with contrast, coarseness and directionality features. The Fig. 10 (b) gives a result example with a query image covered by an ermine texture. The color segmentation method is detailed in the paper [VOG 00]. It removes background shadings to segment color objects using Fourier filters and morphological algorithms. The Fig. 10 (c) gives examples of segmentation results. Tests with practical data show that this segmentation method gives good results when applied semi-automatically.

To combine the different extracted features in the queries the system described in [KIE 98] uses a quick-combine algorithm detailed in [GUN 00]. This algorithm combines multi-feature result lists guaranteeing the correct retrieval of the  $k$  top-ranked results. Its key property is an improved termination test. This test combines the scores assigned to all the ranked items according to a specific form of the combining function. It is used in combination with a heuristic control flow that takes advantage of the scores distribution to address weighted queries. Comparisons done with others algorithms show significant decreases of time processing, in particular

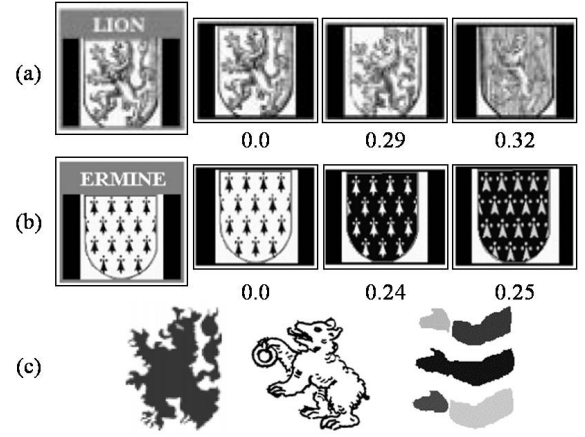


FIG. 10 – Retrieval based on (a) shape (b) texture (c) segmented objects after background removal

for non-uniform score distributions.

The system describes in [PAR 06b] is applied to the retrieval of decorated initials. It employs texture features modeled according to a Zipf law to constitute image signatures. These signatures are built in different steps. First patterns are extracted from images. A pattern corresponds to a gray-level configuration of a pixel and its neighborhood as shown in the Fig. 11 (a). The neighborhood is defined according to a  $3 \times 3$  mask. Based on the 256 possible gray levels, and the use of a  $3 \times 3$  mask, a large number (2569) of patterns can be defined. In order to decrease this number different heuristics are used : a classification tool (a k-mean algorithm) of image gray levels into clusters, a cross mask instead of  $3 \times 3$  mask.

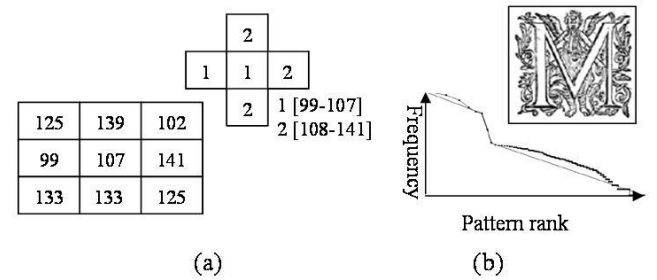


FIG. 11 – (a) a pattern (b) Zipf curve

Using these clustered patterns the system computes next a Zipf curve for each image. It is obtained by ranking the patterns according to their frequency. Fig. 11 (b) gives an example of image and its corresponding Zipf curve. The Zipf curves are then used as image signature. The classification process is done by a  $k$  nearest neighbors (knn) algorithm applied to vectors corresponding to the Zipf curves.

In [UTT 05a], the authors propose a complementary system to [PAR 06b] but based on layout features. To extract the layouts, it employs a segmentation process which splits the images into layers of textured and uniform regions. Fig. 12 (b) (c) gives examples of layers obtained from the image (a). The segmentation process is decomposed into a global and a local analysis. The global analysis is achieved using an uniformity criterion of regions computed from the gray-level

co-occurrence matrix. This criterion allows to segment the uniform regions from the processed images. The other image parts are next used during the local analysis in order to segment the textured regions. This segmentation is decomposed in different steps : computation of a window size for a given texture class, feature extraction for each textured region (co-occurrence and run-length matrixes).

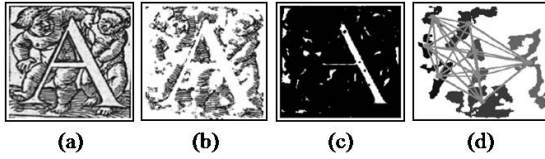


FIG. 12 – (a) image (b) uniform regions (c) textured regions (d) MST of textured regions

The regions are next exploited to compute Minimum Spanning Trees (MSTs). These MSTs are obtained from the region gravity centers and the Euclidean distances between them. Fig. 12 (d) gives an example of MST computed from the textured regions (c). Two MST are built, in independent ways, from the textured and the uniform regions. The lengths of the MSTs allow to constitute feature vectors describing the spatial organization of the initial. The feature vectors are compared using a square distance to achieve the retrieval.

In [KAR 07] the authors extend the previous system [UTT 05a] in respect to the matching step. They build Attributed Relational Graph (ARG) from the uniform regions as illustrated Fig. 13 (b) and (a). In these graphs the nodes represent the region gravity centres and the edges geometric relations between them. The edge attributes describe the Euclidean distances between the gravity centres but also trigonometric relations. These relations are computed according to the method presented Fig. 13 (c). The nodes are attributed with the region sizes (in pixels) and the first three moments of the Hu descriptor.

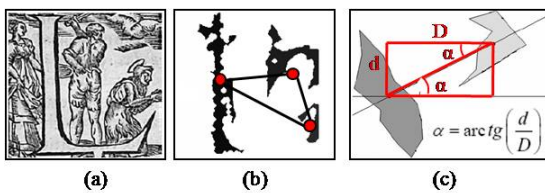


FIG. 13 – (a) image (b) ARG (c) trigonometric distance

Once the graphs built, they are matched using the  $A^*$  algorithm. This algorithm supports the error-correcting sub-graph isomorphism. However, in order to address the NP complexity problem of such an isomorphism, heuristics are used to limit the space solution. The system explores only the matching solutions corresponding to the pairs of the most similar nodes. To do it, a state-space tree is created. In this tree, the levels represent matching results of node pairs from the most similar (top) to the most dissimilar (bottom). The progress in the tree is controlled according to  $K$  threshold, a bottom level is explored only if the distance is lower to  $K$ .

## 6 Discussions

This section reports discussions undertaken by the working group arising from this overview. During the last ten years, large databases of ornaments have been made available on the web and will be bigger in the future [RAM 07]. Therefore, the access to this heritage is nowadays not only restricted to the specialist historians, but opened to the general users (artists, designers, publishers, etc.). The key problem is now to make available these images for research : all of these constituencies have different needs requiring specific means of searching and accessing the information. In all the cases, Digital Libraries and automatic retrieval systems are the key components to do it, however their development is a challenging task due to different key problems :

A first problem is the management of the masses of data today available in respect to the thesaurus. Indeed, the initial objective of historians is to build thesaurus from the image database of ornament using subject-specific classification system like Iconclass. Starting the hypothesis of a Digital Library using an automatic retrieval system in the context of large amount of data, it seems a crucial issue to design an architecture using two types of database [COR 08]. A source database will contain the digitized images and the automated metadata. The ornament thesaurus will describe each image with metadata validated and controlled by human experts. In both cases these databases should be readable/writable from Internet for the general users and experts. It will involve to think about collaborative web platforms using control accesses in the future.

In order to help the historians to build the thesaurus the key task is the block tracking. It looks like an image comparison problem, however it is made harder due to the required precision and the amount of data. In order to address the complexity problem several issues have been explored : image signatures [BIG 96], points of interest [CHE 03], compression space [DEL 07] and image approximations [BAU 08]. In any case, the lack of evaluation of proposed systems makes difficult the choice of a best-suited method. Time experiments have been proposed only in [DEL 07] and classification results in [BAU 08]. To solve such a problem will certainly require system approaches in the future combining high-level signatures (to limit the space solution) and low-level descriptions (for accurate comparison).

Other problem related to block tracking is the visualization. Once the similar printings have been retrieved it remains difficult to notice automatically the relevant differences. This analysis requires expertise of the historians to determine if the printings result of a same block and to make a relative dating. They could be helped in this task using automatic methods of difference visualization [BAU 07a] [BAU 07b]. These methods could be a great help on condition that the images are very well registered. The registration is an real issue because the treated images are moisy, complex and the deformation can be non-linear (e.g. due to different acquisition gear). Starting works on this subject have been proposed in [NIC 08] but needs still to be validated.

The last problem is the design of content-based retrieval systems for general users. Several investigations have been done on this topic using signatures based on shape

[KIE 98] [KAR 07], texture [PAR 06b] [KIE 98] and layout [UTT 05a]. Each of these signatures is a specific mean of searching and accessing the information. In order to take advantage of all these different descriptions, work on feature combination have been also proposed in [GUN 00]. Experiments done using (or combining) these features show promising results. They allow to perform a fast retrieval using global descriptions of images. The open problem concerns the evaluation of these methods. To define a groundtruth for such retrieval application is subjective task that makes harder the system evaluation. Another solution should be to use edit-cost index. In this case, the evaluation will be achieved by the analysis of the corrections made by the users. Another open problem is to describe the images locally. To do it object segmentation methods are mandatory. Such segmentation is an harder task difficult to achieve fully automatically [VOG 00]. Knowledge based approaches will be certainly required in the future to solve this problem.

A last point important to notice here concerns the priority tasks. Discussions of the work group have highlighted a secondary interest of historians for the content-based retrieval applications. Recommendations have been done to consider this topic with a low priority in regard to the previous topics of image enhancement, block tracking and visualization.

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