Watershed for Segmentation the Decor of Zellij

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ABSTRACT
The objective of this work is to propose a segmentation method for retrieval images of Arabo-Moresque decors. It is a hierarchical segmentation using two successive watershed algorithm. The first watershed based on the Meyer's algorithm allows of identifies the germs which serve for the second watershed segmentation to achieve the segmentation. The proposed method is evaluated by using an Arabo-Moresque decor database, built for the ûrpose of this work. The performance of the method is measured by the accuracy to extract the shapes of tiles constituting a décor of Zellij.

Keywords
Color Image Segmentation; tiles extraction, Arabo-Moresque decor; Watershed algorithm; Markers; hierarchical segmentation.

1. INTRODUCTION
Geometric patterns (or zellij in Arabic) [1], [2] make up one of the three types of decoration in Islamic art, which also include calligraphy and arabesque (Figure 1).

(a) (b) (c)

Fig 1: The three types of decoration in Islamic art : (a) Arabesque, (b) Calligraphy, (c) Zellij

In this paper, we are interested in one of the most famous and most beautiful forms of geometric art or Zellij called the Rosette [3] patterns, which begin at a central point and grow radials outward. The central point is a star with 8, 16, 24, 40, 48, 72 and 96 petals, called order of the rosette. Then, the pattern grows by using zellij tiles generated from this central star.
Several works of geometrical patterns modeling as well as automatic methods for indexing and retrieving images of Islamic patterns databases are reported in the literature.
Grunbaum and Shephard [4] decompose periodic Islamic patterns by their symmetry groups, obtaining a fundamental region they use to derive properties of the original pattern. Abas and Salman [5] carry this process out on a vast collection of patterns from every periodic symmetry group. Castera [6] presents a technique based on the construction of networks of eightfold stars and "Safts". In Albert and al. [7] the authors propose a method based on the detection of symmetry in a décor. In Zarghili and al. [8,9] the authors proposed an indexing method based on spatial relationships of the shapes constituting the spine of the decor. In Djibril [10] the authors represent a rosette by its minimal triangle, called fundamental region, by considering the groups of symmetry. Then, the characteristics of the rosette are represented by the color histogram corresponding to the fundamental region.
In [11] the authors propose a novel method for which a rosette is represented by its fundamental region as in [12], [13], and [10]. Then, the fundamental region is characterized by the adjacency graph representing the spatial arrangement of its belonging zellij tiles. We address in this paper the problem concerning the automatic extraction of tiles forming the fundamental region. For this purpose, we propose a watershed segmentation method.

The remainder of this paper is organized as follows. Section 2 is devoted to the definition of the watershed segmentation and these different problems. Section 3 describes the proposed method for segmentation the decor of Zellij and results of our method. Finally, section 4 provides conclusions.

2. SEGMENTATION THE DECOR OF ZELLIJ

2.1 Watershed algorithms
The watershed method has been extensively studied by J.C. Maxwell [14] and C. Jordan [15] among others. One hundred years later, the watershed transform was introduced by S. Beucher and C. Lantuejoul [9] for image segmentation. The watershed transform, classified as a region-based segmentation approach, is now used as a fundamental step in many powerful segmentation procedures [16, 17, 18, 19]. Efficient watershed algorithms based on immersion simulation were proposed by L. Vincent, P. Soille [22,22] and F. Meyer [21] in the early 90's.

2.2 Vincent-Soille algorithm (VSA)
In the first stage; the Vincent-Soille algorithm [22] generates a list of all pixels in the image in height order. At each height level the minima are allowed to spread within the height level. Pixels belonging to the minimum are labeled with the minimum identifier and placed into a FIFO queue. Then the pixel is removed from the queue, and its neighbors are examined. Those at the current height level are given the label

of the pixel from the queue and placed at the end of the queue. This procedure is repeated until the queue runs out, once all the pixels at the current level are labeled. Pixels that have neighbors with a different minimum identifier are marked as watershed pixels. The propagation step is repeated at increasing heights until the entire image is flooded. The watershed results are shown in Figure 2 .

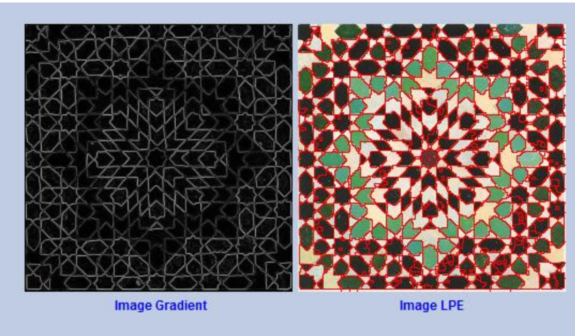

Fig 2 : Examples of watershed segmentation by VSA

Furthermore, this algorithm has some drawbacks:

• Time required.

• The sensitivity to the number of regional minima which is often very important and therefore generates an over-segmentation. In our case the tiles can be divided into component parts, as shown in Figure 4.

3. DESCRIPTION OF THE PROPOSED METHOD.

The watershed produces an over-segmentation of the image, because each local minimum becomes a seed of a new region, but this minimum is not necessarily a point inside a candidate region. The main solution is to select the relevant minimum only. To make it there are several techniques : Color morphology [24], Median Filter, marker, region merging method, hierarchical segmentation which consists in merging some regions from the initial partition .

The proposed method is a two stage process. to produce a primary segmentation of the input image, the first process uses Meyer’s algorithm followed by a filtering operation aiming at to reduce of the number of regional minima. while the second process applies the second watershed segmentation algorithm to the primary segmentation to obtain the final segmentation map.

3.1 Markers approach:

The marker technique was introduced by Meyer [21].Starting from a grayscale image F and a set M of markers with different labels (in our case, these will be the minima of F), it expands as much as possible the set M, while preserving the number of connected components of M:

1. Insert every neighbor x of every marked area in a hierarchical queue, with a priority level corresponding to the grey level F(x). Note that a point cannot be inserted twice in the queue;

2. Extract a point x from the hierarchical queue, at the highest priority level, that is, the lowest grey level. If the neighborhood of x contains only points with the same label, then x is marked with this label, and its neighbors that are not yet marked are put into the hierarchical queue;

Step 2 must be repeated until the hierarchical queue is empty. The watershed lines set is the complement of the set of labeled points. The watershed lines produced by Meyer’s algorithm are always thinner than lines produced by other watershed algorithms.

Fig 3 : Result of watershed algorithm:
(a) Vincent& Soile method, (b) Meyer’s Algorithm

Using the gradient image directly causes over-segmentation because of noise and small irrelevant intensity changes. an improvement is observed by using markers by Meyer's algorithm (Figure 3).

However, we always notice an over-segmentation particularly on the border. To resolve this problem we proposed to filtering the regional minima. For this we will use an operator to remove any germs which the surface of the corresponding region is less than some threshold. This operator preserves the entropy of the distribution of regional minima in the image [25].

The second step is to use a hierarchical segmentation.

3.2 Hierarchical segmentation

The hierarchical approach consists to generate a tree of regions from the result of the watershed [26,27,28,29,30, 31]. Regions and watershed are first indexed, and then the hierarchical segmentation process merges the regions whose common borders are lowest. The result is a tree where it can explore the different levels of fusion regions. Figure 4 shows two segmentations with different levels of mergers.

(a) (b) (c)

Fig 4 : Hierarchical Segmentation. Original Image (b) Result with 83 régions et (c) Result with 226 régions

The second phase of the proposed approach of the segmentation is to apply the second watershed on the output of the first phase of the proposed approach. The center of mass or centroid of a region of the segmented image by the first watershed, which serve as germs for the second watershed segmentation.

Fig 5 Original Images and their segmented version by our method

4. CONCLUSION.

The watershed transform is more and more used in complex segmentation chains. Among those segmentation procedures, we can cite hierarchical segmentation [29] and geodesic saliency of watershed contours [13, 30]. In this paper, we have shown that Vincent-Soille's algorithms do not preserve important topological features of the image due to its sensitivity to the number of local minima which generates an over-segmentation. In our case the tiles can be subdivided into several components (Figure 2).

To overcome over-segmentation, we propose in this work a hierarchical segmentation method using two successive watersheds. The first watershed based on the Meyer's algorithm, with the filtration of local minima using an operator selection of local minima allowing managing the number of germs in the image. This operator preserves the entropy of the distribution of germs in the image [25].This step allows to identify the germswhich serve for the second watershed segmentation. The results obtained show the performance of the method, applied to images of Zellij. These results will be used in a next phase of characterization tiles extracted and their spatial arrangement.

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