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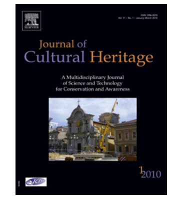

Original article

Geometric rosette patterns analysis and generation

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ABSTRACT

The geometric rosettes, which are the most known design elements of the Islamic rosette patterns, are usually tessellated in a concealed composition structure. To understand and reveal this structure, we propose first to detect and characterize its basic geometric rosettes by using techniques of computer vision and image analysis. Then, the analysis of the spatial arrangement of the detected rosettes, characterized by their respective orders, will reveal the underlying tiling and the mesh grid, together with the harmonious proportions of the design elements. These results are used in turn to generate new innovative and authentic rosette patterns, by using the extracted geometric rosettes and new tile motifs constructed in the basis of an adaptation of the well-known polygonal technique. The performances of the proposed method to reveal the spatial composition of a rosette pattern are tested by the ability to extract its geometric rosettes and by the exact extraction of its underlying composition structure. Finally, the innovative character of the proposed generative method is shown through the creation of new periodic and quasi-periodic patterns characterized by their authenticities and sophistication.

1. Introduction

The artisans of Islamic world continue to perpetuate the practice and the development of Islamic Geometric Patterns (IGP) by preserving the long established tradition consisting to reveal their practical knowledge to a few apprentices. However, as the time passes, the traditional methods of transmission of this ancestral art may be threatened or disrupted. In this context, its preservation as well as its development will be impacted.

Now re-finding or renewing these innovative methods is a concern for today's researchers in the field; this paper is concerned with the use of computer science and related technologies to approach the related problems.

The analysis IGPs shows that they often take the form of a division of the plan into star-like motifs. These commonly used patterns are known as the Islamic star patterns. The geometric rosette is among the many different star-like motifs used in Islamic art, which stands out as distinctively "Islamic". As shown in Fig. 1i, a geometric rosette is defined by 3 concentric circles that pass respectively by the set of points a, b and c. The symmetry order, which is the main distinguishing characteristic of the geometric rosette, is connected with the number of points a, b or c. Fig. 1ii and iii illustrates two geometric rosettes characterized respectively by 12 and 16 folds symmetry.

Fig. 2 gives examples of three types of spatial arrangement of geometric rosettes and stars (design elements). These geometric patterns show that the design elements are tessellated in complex geometrical arrangements, usually in tiles of a tiling, which is used as an underlying structure for the spatial composition. Often, the craftsmen influence the way in which a composition is perceived by emphasizing pattern elements (star/rosette motifs, tiling grid) by the use of the color.

Fig. 2a shows that the rosette motifs, together with the used tiling are highlighted. However, Fig. 2b highlights only the motifs; the used tiling is not explicitly revealed. Otherwise, it is obvious to see that for all the star patterns, rosette motifs and star motifs are the visual anchors that appear in all the compositions. Thus, this paper will focus first on the extraction and characterization of these motifs. The spatial representation of the extracted patterns is then operated by using adjacency graphs. Finally, the analysis of this adjacency graph leads to the determination of some pattern features to be used in the characterization of the pattern and in the process to generate new patterns.

The rest of the paper is organized as follows: Section 2 is concerned with related works focusing methods of analysis and generation of IGPs. Section 3 presents our proposed methods for respectively analyzing and generating a rosette pattern. The proposed analysis method is concerned with respectively the

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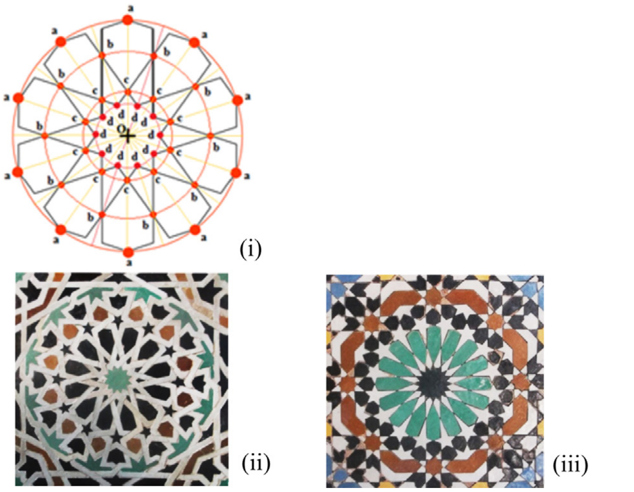

Fig. 1. Examples of geometric rosettes: (i) synthetic rosette according to A.J Lee [13] a: outer points, on circum-circle; b: outer midpoints, on outer mid-circle; c: inner midpoints, on inner mid-circle; d: inner points, on in-circle; o: center of rosette; (ii, iii): geometric rosettes of Zellij style in Fez – Morocco, (ii) rosette with 12 petals, (iii) rosette with 16 petals.
R. Benslimane.

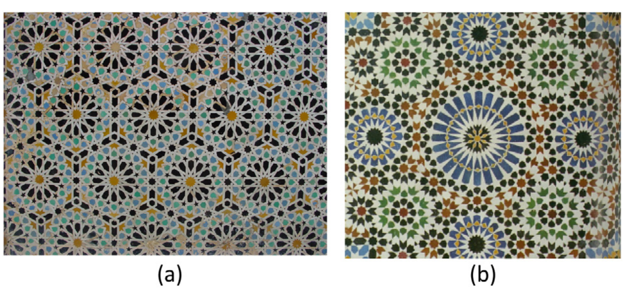

Fig. 2. Examples of three types of spatial arrangement of geometric rosettes: Zellig patterns in Fez-Morocco.
Photos: R. Benslimane.

extraction and recognition of the design elements, the discovering of the underlying spatial composition structures and their representation. Based on the outputs of the analysis phase, the proposed generative method gives a step by step procedure to generate new periodic and a periodic rosettes patterns. Experimental results and discussion are presented in Section 4, and finally, conclusion and perspectives are drawn in Section 5.

2. Related works

Analytical and generation approaches of IGPs can be divided into three main categories: the tiling-based approach, the symmetry groups based approach and the strand-based approach:

- symmetry groups based approach: methods of this approach represent a periodic pattern with its underlying lattice and with its symmetry group [1,2];
- strand-based approach: methods of this approach consider a periodic pattern as drawing lines (Strands); which are linked segments at V-model corners [3,4];
- tiling-based approach: this tiling approach relies mainly on the analysis and generation of ornaments by considering the character of the motifs inscribed in polygons which form the tiling.

In Islamic design traditions, tiling is used as the underlying structures for a composition. A tiling is an arrangement of polygons that can contain design elements. For the star patterns, which are the most sophisticated ones in Islamic art, the well-known design elements are the geometric rosettes.

There are two categories of tiling: tiling using polygons that are periodic and those that are non-periodic. A periodic tiling is a tiling of the Euclidean plane with periodic symmetry. It is proven that all 2D periodic patterns extended by two linearly independent translational vectors can be classified, depending on the type of network or lattice, into five types of unit cells and seventeen symmetry groups [5].

One of the first Western studies of the tiling-based approach was published by E.H. Hankin [6]. The Hankin's technique, known also as polygons in contact technique, was a reference for several works. Kaplan in [7,8] provided a method for rendering Islamic Star Patterns based on Hankin's Polygonal technique. The method builds star patterns from a tiling of the plan and a small number of intuitive parameters.

J. Bonner more recently proved the historical use of this construction technique from his examination of the Topkapi Scroll. Bonner called this polygonal technique. The use of this technique generates a multitude of patterns from a single underlying polygonal tessellation. He proposed in [9] and [10] to create patterns from systematic and non-systematic geometric constructions. He classified systematic patterns into five distinctive systems: the 3-4-6-12 system of regular polygons, the 4-8 system A, the 4-8 system B, the 5-10 system, and the 7-14 system. The non-systematic patterns are characterized by more than a single region of higher order star-forms.

Castera in [11] summed up the rules for the Moroccan Zellij patterns construction, when he introduced the concept of skeleton. The skeleton is an underlying structure, made up of the alternation of two tiles: the octagonal star and an irregular hexagon called "Saft". Fig. 2a gives an example of skeleton. The point is that the skeleton follows the outline of a network similar to a tiling. This particular tiling is constituted by polygons and different star shapes.

In this tiling-based approach, motifs inscribed in the polygons in contact can be considered as separate mini-compositions. Recognizing and characterizing these design elements and their spatial arrangement opens the way to a better understanding of the design process. This paper proposes, first, to detect these motifs by using an improved version of our recent developed method [12]. Then, we propose to represent the spatial relationship between the detected motifs by an adjacency graph. From the analysis of this spatial representation, we finally extract the hidden tiling, the repetitive unit cell and other pattern settings. An original generative method, based on the analysis outputs, is finally proposed to create new rosette patterns.

3. Proposed method for rosette pattern analysis and generation

In this paper, we propose a new method to analyze and generate a rosette pattern based on two stages, the first stage consist to analyze an input image of a rosette pattern by using image analysis techniques. The outcomes of this analysis stage (adjacency graph, hidden tiling, and other pattern settings) are used in turn in the second stage for the generation of new rosette patterns.

3.1. Proposed method for rosette pattern analysis

In [12], we proposed an original method to detect and characterize rosettes of a geometric rosette by performing the following stages:

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