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# A distinct and compact texture descriptor☆

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ABSTRACT

In this paper, a statistical approach to static texture description is developed, which combines a local pattern coding strategy with a robust global descriptor to achieve highly discriminative power, invariance to photometric transformation and strong robustness against geometric changes. Built upon the local binary patterns that are encoded at multiple scales, a statistical descriptor, called *pattern fractal spectrum*, characterizes the self-similar behavior of the local pattern distributions by calculating fractal dimension on each type of pattern. Compared with other fractal-based approaches, the proposed descriptor is compact, highly distinctive and computationally efficient. We applied the descriptor to texture classification. Our method has demonstrated excellent performance in comparison with state-of-the-art approaches on four challenging benchmark datasets.



## 1. Introduction

Visual texture, a powerful cue for characterizing scene structures that exhibit a high degree of similarity in their image patterns, provides a rich semantic description for many computer vision tasks such as image understanding, scene classification and visual retrieval. Although there is an abundant literature on texture description, developing an effective and efficient texture descriptor remains a challenging problem. A desired texture descriptor should be highly discriminative and robust to environmental changes, such as illumination changes, occlusions, non-rigid surface distortions and camera viewpoint changes. Meanwhile, the descriptor should be compact and computationally feasible for real-world applications.

In the past, a number of approaches [1–9] for texture description have been proposed to achieve robustness against environmental changes. The basic idea of these approaches is to compute a global description based on some local texture features. One popular approach to local texture description is the so-called local binary pattern (LBP) [10]. The LBP and its variants [11–16] have been demonstrated to be effective in describing local image patterns and classifying materials. However, the performance of the existing LBP-based methods in recognizing random texture in real scene is very limited. The reason is that most of these methods use simple histogram-based statistics to integrate local features. Such histogram-based statistics only count the number of elements and lose the details of how the elements are spatially distributed.

One promising alternative to the histogram-based statistics is the fractal-based approach [17–22] that characterizes the spatial distribution of elements using fractal geometry. Many fractal-based approaches have been successfully used in texture classification. However, in the existing approaches, often the features are highly redundant. For instance, the gradient and Laplacian multi-fractal measurements used in [19,23] would provide similar information about edges, and the descriptor proposed in [18] is insufficiently compact (1218-dimensional). Some approaches involve large-scale clustering (e.g., [17]) or some complex alignment stages (e.g., a tight frame system is involved in eXuHJF12CVIU) and as a result, the computational cost becomes expensive.

In this paper, we are motivated to combine the power of the local pattern coding strategy and the global fractal analysis. Built upon the local binary patterns of image, a practical fractal-based texture descriptor is developed. An input image is first represented by local binary patterns, and then fractal dimension is computed on each type of pattern and all the fractal dimensions are finally concatenated as a feature vector. Owing to the effective LBP-based local representation, the proposed descriptor becomes compact. Meanwhile, benefitting from the robust fractal analysis, the proposed approach enjoys both high discriminative power and robustness against many environmental changes. We applied our descriptor to texture classification on four challenging benchmark datasets. The proposed approach has exhibited excellent performance in both effectiveness and efficiency in comparison with state-of-the-art approaches.

The remainder of this paper is organized as follows. Section 2 reviews related works on texture descriptor for texture classification. Section 3 introduces some background knowledge about local binary patterns and fractal analysis. Section 4 is devoted to the proposed

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0262-8856/

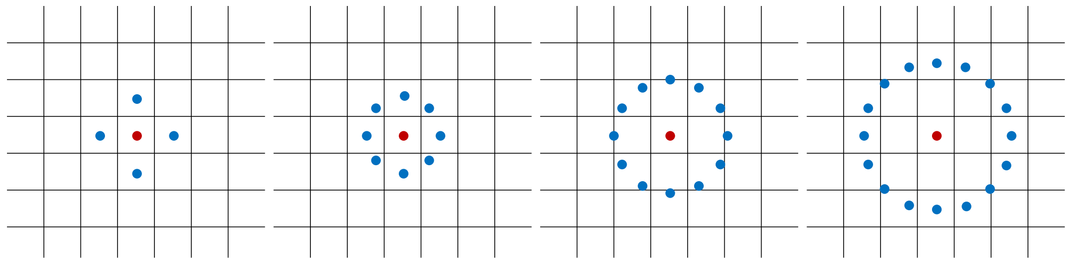


**Fig. 1.** Circularly symmetric neighborhood used in $LBP_{P,R}$. The red point denotes the center pixel $g_c$ and the blue points denote the sampling points $g_p(p = 0, 1, \ldots, P-1)$.

approach. The experimental evaluations are reported in Section 5 and the conclusion is drawn in Section 6.

## 2. Related work

In this section, we first have a brief review on recent studies of texture classification that are most relevant to our work. Secondly, some LBP-based approaches to texture classification are mentioned. Finally, we focus on the fractal-based approaches.

### 2.1. Texture classification

Many modern texture classification approaches [2,5,6,24–26] model texture patterns using the statistics of spatial texton distribution. The basic idea is to extract local features through random sampling or robust feature detection and construct a texton codebook by performing vector quantization on a set of randomly selected local features. Then some statistical measurements (mostly histogram-based) are computed with the help of the texton codebook. The seminal work can be traced back to the approach introduced by Julesz [27] and such an approach has been studied by many other researchers (e.g., [28,29]). The main advantage of such methods is that the local feature descriptors have strong robustness to geometric and illumination changes, as well as partial occlusions. One representative work is the texture representation approach proposed by Lazebnik et al. [30]. The approach first characterizes the texture by clusters of elliptic regions, and the elliptic regions are then normalized to circles for the invariance to affine transforms. Two types of descriptors, spin image and RIFT (Rotation Invariant Feature Transform), are defined on each region. The resulting texture descriptor is the histogram of clusters of these local descriptors, and different texture descriptors are compared using the earth mover's distance [31]. This approach was comprehensively evaluated in [26] and has demonstrated promising performance on the applications of texture classification and retrieval on several benchmark datasets.

### 2.2. LBP-based approach

The concept of LBP is first introduced by Ojala et al. [10] and has been widely used as local feature for texture description. In [12], multi-scale LBPs were used for texture classification. The texture description is based on the joint distribution of the LBPs. Liao and Chung [13,32] adapted the LBP coding strategy to the local dominant structures of texture by sorting the patterns according to their occurrence frequencies. The distribution of the LBPs is characterized by the co-occurrence statistics. Guo et al. [14] proposed to weight the LBP histogram by the local variance of the LBP codes. The weighted histogram is aligned to the principle orientation of image and matched by exhaustive search. In [15], the magnitudes as well as the signs of local image differences are utilized in the LBP coding strategy. The joint and hybrid distributions of the LBPs characterized by histogram are used for texture recognition. To enhance the robustness to rotation, Fourier transform is applied to LBP histogram in [33,16]. All of these methods have achieved satisfactory results on certain texture datasets, whereas their application to more challenging texture recognition tasks is very limited.

### 2.3. Fractal-based approach

One main attractive property of the fractal-based approach is its ability of capturing the self-similarities [1] of spatial distribution of textons, which is an essential characteristic of texture patterns. The early works [34–36] describe texture mainly using fractal dimension or the parameters of certain fractal models. The discriminative power of these methods is very limited. Recently, Xu et al. [19,23] have made a progress

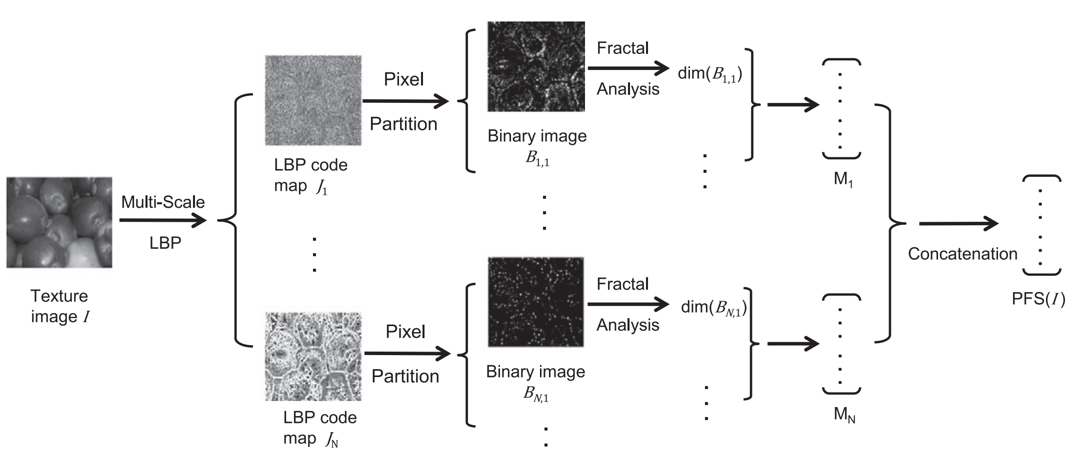


**Fig. 2.** Flowchart of the proposed descriptor.