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Hybrid Region and Edge Based Unsupervised Color-Texture Segmentation for Natural Images

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The paper proposes a generic color-texture feature integration framework. We propose two variants of edge based texture capturing method using filter banks of tensor products obtained from Orthogonal Polynomials (OP) - OP3 of order 3 and OP5 of higher order 5 which are applied on Hybrid Color Space (HCS) for color texture feature integration. A region based unsupervised segmentation algorithm is applied on each of the variant's Adaptive Feature Vector Representation (AFVR). The segmentation starts with classical K-means clustering in an iterative manner controlled by Kolmogrov-Smirnov (KS) test. A spatially constrained merge step acts as a post processing step to address over-segmentation. A segmentation tree is constructed in a hierarchical fashion generating metadata for cluster and regions separately. The algorithm is successfully tested quantitatively on 300 natural images from Berkley Standard Dataset using Probability Rand Index (PRI), Boundary Displacement Error (BDE), Variance of Information (VOI) and Global Consistency Error (GCE) which are widely used segmentation metrics found in literature. Experimental evidences are gathered showcasing the strength of color texture segmentation using OP3-HCS, OP5-HCS when compared with only color feature segmentation. A case study analysis indicates OP5 is biased towards over-segmentation as compared to OP3. Experimental results demonstrate the inherent simplicity and effectiveness of the proposed OP-HCS based hybrid color-texture image segmentation by achieving an average of 74 percent on PRI and at the same time having good balance on the rest of the three BDE, GCE and VOI measures. The results have been compared with other segmentation methods and found to be competitive.

Keywords : Color-Texture Feature Integration, Hybrid Color Space, Orthogonal Polynomial Operators

1. INTRODUCTION

The natural images reveal significant complexity as color and texture varies for every other case. Hence unsupervised segmentation of the natural images is still an open area of research. Color is crucial to many pattern recognition and computer vision tasks as its higher dimension aspect adds additional information as compared to the intensity gray shades. The textures present in natural scenes are irregular and non-periodic in nature. The color-texture feature measurement can be basically divided into two categories - 1) methods that extract color and texture features separately and 2) methods that perform fusion of both color and texture features as a joint phenomenon. Color and texture features are the two most significant attributes that complement each other. Our approach considers both color and texture as a joint phenomenon upon which segmentation has been found quite effective. In the field of computer vision, several important contributions are made in color-texture feature extraction and color image segmentation.

Image segmentation approaches can be broadly classified into two groups, based on homogeneity or based on discontinuity of pixel properties. Homogeneity based approaches or the region techniques consist of thresholding, region split and merge, region growing and clustering whereas the discontinuity based approaches refer to edge detection or contour techniques. Region based segmentation methods use clustering extensively to group the coherent regions

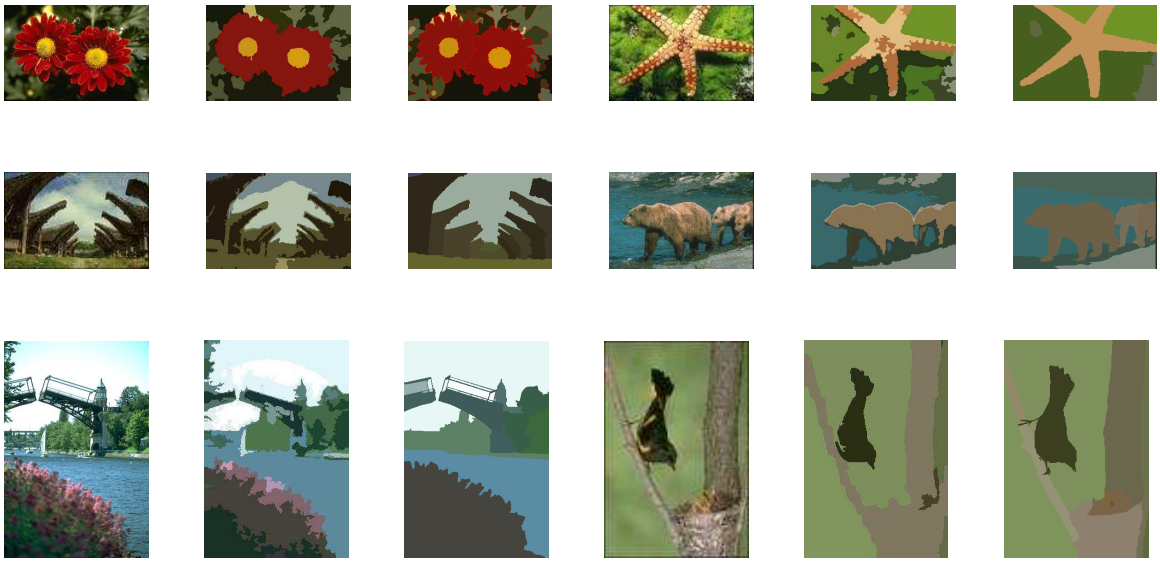

Figure 3. Each Set of Images Contain 1. Original Berkeley Image, 2. OP3-HCS Segmentation, 3. One of the Many Human Segmention

as compared to OP5-HCS. Segmentation results of few BSD300 images using OP3-HCS are shown in Figure 3.

8. CONCLUSIONS

Experimental results demonstrate the effectiveness of the hybrid region and edge based color-texture unsupervised segmentation framework. We have established two variants of our method OP3-HCS and OP5-HCS based on the use of filter banks of tensor products obtained from orthogonal polynomials of order 3 (OP3) and order 5 (OP5) that are applied and experimented on chrominance dominant hybrid color space (HCS) for color-texture segmentation. The distinctive features of our framework include adaptive feature vector representation, iterative K-means clustering using cluster similarity test based on histogram analysis and KS Test. The segmentation tree is constructed in a hierarchical fashion where the clusters and regions obtained at each level can be labeled as toned or textured depending on test statistic threshold. The parameter settings used is one time initialization. The choice of parameters adds flexibility between under-segmentation and over-segmentation. The segmentation is successfully tested quantitatively on 300 natural images from Berkley Standard Dataset using PRI, BDE, VOI and GCE. Segmentation results exhibit the effectiveness by achieving on an average 74 percent on PRI which is quite encouraging without involving any preprocessing, training or smoothing processes. The inherent simplicity of the generation of color-texture framework using OP-HCS (OP3 or OP5) exemplifies satisfactory clustering performance in computationally efficient manner.

The paper concludes with some experimental findings on segmentation - 1) HCS proved to be better than RGB 2) OP3-HCS is better for coarser level image segmentation and can be applied for high-level recognition tasks. OP5-HCS is biased towards over-segmentation as non-linearity gets captured using larger window size and may be an ideal option for texture characterization. 3) OP3 and OP5 have performed considerably better than Gabor for

all color spaces in terms of PRI and BDE and results of VOI and GCE are found to be comparable. 4) OP3-HCS and OP5-HCS are compared to 11 recent and popular state-of-art methods - four graph based clustering methods, four clustering based on probability density function and mixture models, bit domain method, fusing contour and gradient features method and a color histogram method. We understand that the list is not exhaustive; still it gives us a comparative estimate with other segmentation methods. Though we could not surpass the best measures, the four metric measures are found to be quite encouraging especially performed in a time-efficient manner (approx. 43 seconds).

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