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Simultaneous Separation of Low Level Features in Color Images using Orthogonal Polynomials

R. Krishnamoorthy[1*], S. Thennavan[2], R.G. Harini[3] and K.K. Manisha Narayani[4]

[1,2,3,4]Department of IT &CSE ,University college of Engineering-BIT Campus-Tiruchirappalli, India-620024

[*]*Corresponding Author: rkrish26@hotmail.com, Tel: +917708412211*

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Abstract--- In this paper, a new method for simultaneous separation of features in color images using Orthogonal Polynomials is proposed. The low-level features,edge and texture present in the color image under analysis are extracted simultaneously in frequency domain usingOrthogonal Polynomials Transformation. The transformed coefficientsobtained from Orthogonal Polynomials Transformation are categorized into color coefficients, texture coefficients and edge coefficients based on the linear contrast due to Orthogonal Polynomials Transformation in different coordinate axes. A Simplified Gradient Measure approach (SGM approach) is used to extract the edge and texture part of the color image from the categorized coefficients simultaneously after careful examination and representation of color textures. The proposed method is tested with various standard color texture images. The results obtained using this proposed feature separation method is encouraging**.**

Keywords---Edge extraction, Feature extraction, Orthogonal Polynomials Transformation, Textureextraction.

I. INTRODUCTION

In the field of Image processing, feature extraction is one of the hefty task, particularly extracting features from a color image is a tedious process. Generally it is suggested to extract the features of an image in frequency domain than spatial domain due to its computational efficiency. The pixel values of an image can be converted from spatial to frequency domain using any of the unitary transformation such as Discrete Cosine Transformation (DCT), Orthogonal Polynomials Transformation (OPT), Integer Wavelet Transformation (IWT) etc. From the existing literature it is observed that, works on extracting both edgeand texturefrom a color image simultaneously is rare and hence this proposed method concentrates on extracting these features simultaneously from a given 3D color image. The rest of the paper is organized as follows. Section II presents the literature related to the proposed method. Section III describes the mathematical model of the proposed feature extraction scheme followed by the architectural representation in section IV. The proposed low level feature extraction technique is explained in section V and the experiments and results are briefed in section VI. Conclusion part is drawn in section VII.

II. LITERATURE SURVEY

Many algorithms have been used for extracting features of images. Specifically, color feature extraction on images is done with many techniques such as Self Organizing Map, Canny Edge Detection, Finding Gradients, Gabor Filter as suggested in [1, 7]. In [9] features are extracted using neural network based deep learning approach. Lu & Chang [5] utilized color distribution scheme to represent the color feature for content based image retrieval system with statistical properties, mean and standard deviation. The mandatory low level featuresfor any images are color, edge and texture. Detection of edges is quite easy as compared to texture. Edge identification in both textured and untextured 2D images is performedusing SNR, local descriptors and global descriptors in [3]. A conventional image hashing algorithm is used to extract the color features of texture images in [8]. In [4], the edges present are identified using the contribution of transformed coefficients using Orthogonal Polynomial Transformation. In [6] a simplified GLCM approach is provided for the feature extraction. In [2] a linear method for analyzation of both the edge and texture in monochrome images, with the help of Orthogonal Polynomials is discussed.The use of orthogonal polynomials is highlighted here due to its decorrelation property.

III. MATHEMATICAL MODEL

In this section the mathematical model of the proposed low level feature extraction scheme is presented. Assume that*x* and *y* represent the two spatial coordinates and *z* indicates the color space which is based on classical definition of color image, then the color image formation *I(x, y ,z)* can be described as

$$I(x,y,z)=\iiint f(\xi,\eta,\gamma)\,d\mu(\xi)d\mu(\eta)d\mu(\gamma) \qquad (1)$$

where $\xi, \eta, and\ \gamma$ are coordinates in the 3-D space, the object function $f(\xi,\eta,\gamma)$ is integrable on a measure space and μ is a σ finite measure with an infinite number of points of increase. The image I can be considered to be a signed measure on the ring of all measurable sets. The three dimensional point-spread function $M(x, y, z)$ is considered to be real valued function defined for $(x, y, z) \in X \times Y \times Z$ where X, Y and Z are ordered subsets of real values. In the case of a color image of size $(n \times n \times n)$ where X (rows) consists of a finite set, which for convenience can be labeled as {0, 1, …,n-1}, the function $M(x, y, z\}$ reduces to a sequence of functions

$$M(i, x) = u_i(x)\ ,\ \ i = 0, 1, ..., n-1 \qquad (2)$$

As shown in equation (2), the process of color image analysis can be viewed as the linear transformation defined by the point-spread operator $M(x, y)$ $(M(i, t) = u_i(t))$

$$\left|\beta'(\mathrm{i, j, k})\right|_{(i,j,k)\in S\times S\times S} = \int_{x\in X}\int_{y\in Y}\int_{z\in Z} \mathrm{M}(\zeta,\mathrm{x})\mathrm{M}(\eta,\mathrm{y})\mathrm{M}(\mathrm{s,z})\mathrm{I}(\mathrm{x,y,z})\,\mathrm{dxdydz} \qquad (3)$$

where $i, j, and\ k$ are coordinates in the 3-D transformed space. Considering each of X, Y and Z to be finite set of values {0, 1, …,n-1} equation (3) can be presented as,

$$\left|\beta'_{ijk}\right|_{i,j,k=0}^{n-1} = (|M| \otimes \left|M \otimes |M|\right)^t |I| \qquad ....(4)$$

where the point spread operator $|M|$ is

$$|M| = \begin{vmatrix} u_0(x_0) & u_1(x_0) & \cdots & u_{n-1}(x_0) \\ u_0(x_1) & u_1(x_1) & \cdots & u_{n-1}(x_1) \\ & & \vdots & \\ u_0(x_{n-1}) & u_1(x_{n-1}) & \cdots & u_{n-1}(x_{n-1}) \end{vmatrix} \qquad (5)$$

$\otimes$ is the outer product and $\left|\beta'_{ijk}\right|$ be the n^3 matrices arranged in the dictionary sequence that takes the effect of individual R, G and B planes as well as interactions among the color planes. $|I|$ is the image and $\left|\beta'_{ijk}\right|$ be the coefficients of transformation. These $\left|\beta'_{ijk}\right|$ transformed coefficients obtained with the orthogonal polynomials take the effect of individual color planes as well as the interactions among the color planes due to the outer product operations. Considering the set of orthogonal polynomials $u_0(x), u_1(x), ..., u_{n-1}(x)$ of degrees 0, 1, 2, …,n-1, respectively. The generating formula for the polynomials is as follows.

$$u_{i+1}(x) = (x-\mu)u_i(x) - b_i(n)u_{i-1}(x) \quad for\ i \ge 1, \qquad (6)$$

where $u_1(x) = x - \mu, \quad and \quad u_0(x) = 1,$

$$b_i(n) = \frac{\langle u_i, u_i \rangle}{\langle u_{i-1}, u_{i-1} \rangle} = \frac{\sum_{x=1}^{n} u_i^2(x)}{\sum_{x=1}^{n} u_{i-1}^2(x)} \quad and \quad \mu = \frac{1}{2}\sum_{x=1}^{n} x$$

Considering the range of values of $x$to $x = i, \quad i = 1, 2, 3, ..., n,$ we get

$$b_i(n) = \frac{i^2(n^2 - i^2)}{4(4i^2 - 1)}, \quad \mu = \frac{1}{n}\sum_{x=1}^{n} x = \frac{n+1}{2} \qquad (7)$$

Next, we construct point-spread operator's $|M|$s of different width from the above orthogonal polynomials using equation (5).

A. Orthogonal Polynomials Basis

The finite set elements of R-G-B color space are labeled …..(3.3 as {1,2,3}. The finite Cartesian coordinate set S, X and $Y$are also labeled in the identical manner. Thepoint spread operator in equation (4) that defines the linear orthogonal transformation of color images can be obtained as $|M| \otimes |M| \otimes |M|$ in which $|M|$ can be computed and scaled from equation (5) as follows.

$$|M| = \begin{vmatrix} u_0(x_0) & u_1(x_0) & u_2(x_0) \\ u_0(x_1) & u_1(x_1) & u_2(x_1) \\ u_0(x_2) & u_1(x_2) & u_2(x_2) \end{vmatrix} = \begin{vmatrix} 1 & -1 & 1 \\ 1 & 0 & -2 \\ 1 & 1 & 1 \end{vmatrix} \qquad (8)$$

The set of 27 three dimensional polynomial basis operators $O_{ijk}(0 \le i,\ j,\ k \le n\text{-}1)$ can be computed as

$$O_{ijk} = \hat{u}_i \otimes \hat{u}_j \otimes \hat{u}_k \qquad (9)$$

where$\hat{u}_i$is the $(i + 1)^{st}$column vector of $|M|$. The operator $O_{ijk}$is arranged in the dictionary sequence in such a manner that it becomes the $(i \times 3^2 + j \times 3 + k) + 1^{st}$ column vector of the point-spread operator $|M| \otimes |M| \otimes |M|$ in equation (4)

IV. ARCHITECTURE

In this section, the architecture diagram for the proposed feature separation method using orthogonal polynomials transformation is presented. The image for which features need to be separated is the input for the system and the extracted feature image is the output of the system. The pixel values represented in spatial domain are converted to frequency domain using Orthogonal Polynomials Transformation from which the texture features, edge features and color are modeled to separate simultaneously using the proposed feature separation scheme. The working of the proposed system is presented in Fig 1.

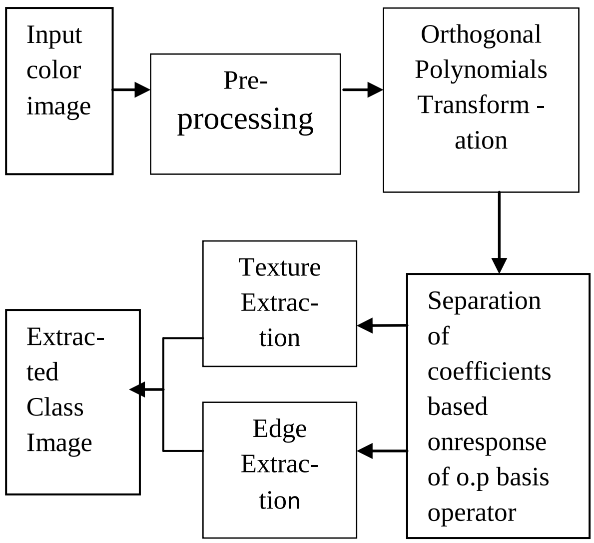

Fig 1 Architecture diagram for the proposed feature extraction system

V. PROPOSED LOW LEVEL FEATURE EXTRACTION

A. Preprocessing

Initially a color image of size (256x256)is taken as input. To know the significance of each coefficient, analyzing the pixels as transformed coefficients in frequency domain is highly efficient than analyzing in spatial domain due to its uncorrelational behavior. For the sake of computational simplicity, the basis operator for orthogonal polynomials transformation is fixed of size (3x3). Hence to match up with the basis operator, the input image is divided into blocks each of size (3x3). In order to make the detection accurate and clear, the blocks are divided in the overlapping format.In the preprocessing stage, the color components R, G, B are extracted as x, y, z coordinates from the pixel values and are assembled in a way that the corresponding x, y, z coordinates are arranged in increasing order. Thus for every (3x3) block a corresponding (27x1) matrix is constructed which consists of 9 x, y, z coordinate valuescorrespondingly for 9 pixel values. The preprocessed matrix is termed as the input block. The input block is then subjected to Forward Orthogonal Polynomials Transformation and the transformed coefficients are obtained.

B. Feature Extraction

Each transform coefficient in the frequency domain represents unique information. The transformed coefficients are written in this proposed work as

$$|\beta'_{ijk}| = \begin{vmatrix} \beta'_{000}\beta'_{001}\beta'_{002} & \beta'_{010}\beta'_{011}\beta'_{012} & \beta'_{020}\beta'_{021}\beta'_{022} \\ \beta'_{100}\beta'_{101}\beta'_{102} & \beta'_{110}\beta'_{111}\beta'_{112} & \beta'_{120}\beta'_{121}\beta'_{122} \\ \beta'_{200}\beta'_{201}\beta'_{202} & \beta'_{210}\beta'_{211}\beta'_{212} & \beta'_{220}\beta'_{221}\beta'_{222} \end{vmatrix} \quad (9)$$

The linear contrast of the transformed coefficients along x, y, z coordinatesis modeled in this work tocontribute the features of the images such as color, edge and texture. The transformed coefficient value corresponding to the zero scale at x, y, z coordinate ie.,(β'_{000}) is modeled as DC coefficient and the other coefficients that are obtained by varying the x, y and z coordinates are termed as the AC coefficients. After various level of analyzation, is it strongly recommended that the linear contrast variation along the z coordinate by keeping the x and y coordinates on zero scale contributes to the color feature of an image. The transformed coefficients that correspond by varying the linear contrast along the horizontal and vertical direction as mentioned in the representation (9) contributes to edge feature of the image. The transformed coefficients obtained by varying the linear contrast at scale 1 and 2 for the x and y coordinates and through all scales for z coordinateis modeled to, contribute the texture feature of the image.Thus the color, edge, texture features of a color image can be separated simultaneously by processing the transformed coefficients that correspond to the particular feature. The extracted coefficients are treated with a simplified gradient measure approach where a varying threshold value is used to identify the presence of the texture feature or edge feature in a particular (3x3) block. A threshold is calculated for every image based on its feature properties which is used as the limitage criteria for finding out the presence of edge and feature in every divided block.The method canbe presented as an algorithm as specified below.

Input **:** color image Output **:** Feature separated image.

Step 1 : Begin
Step 2 : Input color image
Step 3 : Divide it into blocks of size (3x3) and perform the preprocessing steps required for FOPT as mentioned in section V.A
Step 4 : Compute the transformed coefficients using forward Orthogonal Polynomials Transformation
Step 5 : Categorize the coefficients that corresponds to color, texture, feature and treat with SGM approach as described above.
Step 6 : Print the feature extracted image
Step 7 : End

VI. EXPERIMENTS AND RESULTS

The proposed feature separation method is implemented and tested over 200 standard benchmark color images. The texture images are taken from brodatz set. As a sample, the feature extraction done for the images Peppers (Fig 2(a)) and Brick (Fig 2(b)) of size (256 x 256) in color mode is presented in this section. The input image is divided into (3x3) block and forward OPT is applied to each block. After extracting the edge and texture coefficients, the Simplified Gradient Measure approach is performed as described in section V.B For clear classification the extracted edge portion is represented using red color and the texture portion is represented using blue color in the feature extracted image of the proposed system. The corresponding output of Fig 2(a) and 2(b) is pictured in Fig 3(a) and 3(b) respectively. The output of the proposed method is compared with existing conventional schemes and is found to be encouraging.

(a) (b)
Figure 2: Input images (a)Peppers (b) Brick image

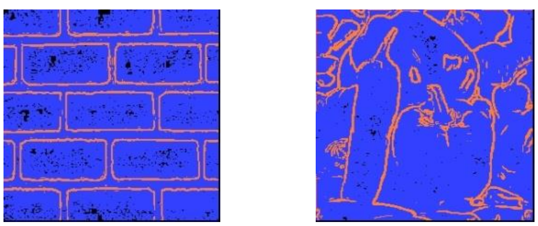

Fig 3(a) Fig 3(b)
Figure 3: Results of proposed Feature Extracted images corresponding to the orginal images shown in Figure 2.

VII. CONCLUSION

In this paper a new scheme for simultaneous feature separation for color images using Orthogonal Polynomial Transformation is proposed. This proposed method for feature separation is found to be elegant and easily implementable than many conventional methods. The results of feature separation using the proposed scheme are also encouraging. This work has its future scope for extracting the features of frames from a video in orthogonal polynomials domain.

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Authors Profile

Dr.Krishnamoorthy Ramasamy (M'91) was born in Thiruvarangam, India, in 1961. He received the M.Sc. degree in mathematics from Madurai Kamaraj University, Madurai, India, in 1983, the M.Tech. degree in computer science and engineering from the Indian Institute of Technology Kanpur, India, in 1992, and the Ph.D. degree in digital image processing from the Indian Institute of Technology Kharagpur, India, in 1999. From 1983 to 2006, he was a faculty member of Annamalai University, Chidambaram, India. Since 2006, he has been a Professor with the Computer Science and Engineering Department, Anna University—BIT Campus, Tiruchirappalli, India. He has authored seven books and over 183 articles. He has guided 23 scholars and obtained four research and development projects worth Rs. 65 lakhs, from various government funding agencies. His current research interests include computer vision, image processing, and data mining. Dr. Krishnamoorthy was a recipient of the Rashtriya Gaurav Award, the Indira Gandhi Shiromani Award, the T. C. SrinivasaIyengar Sanskrit Medal, and the Rao Bahadur Sri R. NarasimhaIyangar Prize. He is a member of ACM, CSI, and ISTE.

Mr. Thennavan Selvaraj was born in Trichy, India in 1980. He received the B.E. Degree in Computer Science and Engineering from Bharathidasan University, Tiruchirappalli, Tamilnadu, India in 2001 and the M.E. degree in Computer Science and Engineering from Annamalai University, Tamilnadu, India in 2009. He received the Ph.D.in Digital Image Processing in 2018. He has 14 years of experience in University Data Center and research, in Department of Computer Science and Engineering. Currently he is working as Systems Assistant in the Department of Computer

Science and Engineering, Anna University, BIT Campus, Tiruchirappalli, India, since 2010. He has published research articles in National Journal and International Conferences.

*Ms. Harini*was born in Chennai, Tamilnadu, India in 1997. She is persuing her B.Tech degree in the stream of Information Technology in Anna University-BIT campus, Tiruchirappalli, Tamilnadu ,India. She has published research articles in International Conferences.

Ms. Manisha Narayani was born in Kanyakumari, Tamilnadu, India in 1996. She is persuing her B.Tech degree in the stream of Information Technology in Anna University-BIT campus, Tiruchirappalli, Tamil nadu ,India. She has published research articles in International Conferences.

