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A Novel Approach for Color Image Edge Detection Using Multidirectional Sobel Filter on HSV Color Space

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***Abstract*—Edge detection is a very commonly adopted operation in any pattern recognition task like image segmentation as edges are the prominent features which form the outlines in an image. Detecting edges for a color image is a bit difficult than the same in a gray image. In this paper, a novel approach for edge detection in color images is proposed. This approach is based on Multi-directional Sobel filter. For the color arrangement, HSV color space is used. The experimental results demonstrate the efficiency of the proposed approach.**

Keywords-Color Image;Color Space;edge detection;HSV; RGB;Sobel Filter;Multi Directions

I. Introduction

Edge detection can be regarded as the most important task in pattern analysis and recognition. This is used in almost every image analysis fields like image segmentation, object recognition, target tracking etc[1]. An edge in an image consists of very important and meaningful feature and thereby carries significant information with it. By edge detection techniques we try to localize the distinct edges in an image. By distinct edges, we mean that there should not be two edges for the same brightness in case of gray image and for the same color in case of color images. Because of its prominent applications, edge detection now becomes a fundamental part of growing image processing research. When edges are detected, then with respect to the concerned application, the information which is less relevant can be filtered out and those which are of the current point of interest can be tracked out [2] [3] [4]. In this way, edge detection also helps to remove unnecessary redundancies that may exist in an image and hence results in the reconstruction of a more relevant image of smaller size.

Edge detection also helps in image segmentation. This is because edges are often found to occur at boundaries where regions of interests (or objects) are located in an image. So, detecting edges simultaneously separates the different region of interests from each other. It is often seen that edge detection techniques are commonly adopted in image segmentation approaches for better results [5] [6].

Edge detection techniques are categorized into two main types: 1. Gradient-Based and 2. Laplacian-Based. In the first type, the edges are detected by finding the maximum and minimum in the first derivative of the image [3] [7]. While in the second type, searches are made for finding the zero-crossing in the second derivative of the image to detect the edges of the image involved.

We have adopted the first kind to our proposed approach as gradient-based edge detection techniques involve less complexity than the Laplacian-based techniques. It has the capability of producing smoothing effect to random noises [8].

The gray image carries less information than a color image. Our human eyes are more sensitive to brightness and hence, can identify thousands of color at any point of a complex image, but at the same time, they can identify only a dozens of grayscale [9].So, nowadays, color image processing is gaining more attention and hence more research is going on this field. Edge detection in color image is a more complex task than detecting the same in gray image. But, in the literature, only a few state of the algorithms exist for detecting edges in color image. Maximum of them suffer from the problems that edge detected are not clearly visible, not thick and hence leads to miss-identification of patterns or region of interests. From the literature, it is found that maximum authors are adopting RGB color space for performing the color computations involved. But, RGB color space is not suitable for this task, since this has three channels where every channel is attached to brightness. There is no such single channel in RGB color space which is fully devoted to luminosity. So, it needs to apply convolution in every channel and then recombine all the three to get the final image. It involves a high complexity. Also, RGB color space is a device dependent color space. These are the reasons we do not go for RGB color space and adopted HSV color space our task.

The remaining portions of the paper are designed as follows:

In section II, a brief survey of some remarkable work done in the area is provided. From section III to section V, the technical concepts are discussed with examples. Section VI is the experimental section and conclusion is presented in section VII.

II. LITERATURE SURVEY:

In [2], the authors proposed an improved Sobel edge detector. Here, a soft-threshold wavelet is applied for denoising to do the edge detection for the images consisting of Gaussian noise. The experimental results prove the efficiency of the proposed approach.

In [8], the authors proposed a color edge detection technique based on the combination of Sobel filter and Principal Component Analysis(PCA). The proposed technique succeeds to produce better results than the other classical methods. Global Measures of Coherence is used to compare the performance.

In [10], the authors proposed an approach for detecting edges in a color image where they represent a color image by a vector field, and the edges are detected on the basis of the difference in the local vector statistics like local variations in color or spatial image properties. The main feature of the proposed approach is that it is not only considering the edge magnitude but also considering the local edge direction.

In [11], the authors are performing a comparative study on different approaches to edge detection of edge detection for color images. These approaches are based on the transformation of RGB image to YUV and YCoCg and back to RGB color space again. Laplacian and Gradient operators are used for detecting the edges.

In [12], the authors proposed a color image edge detection algorithm in RGB color space. Here, they used average maximum color difference value to predict the optimum threshold value for a color image. Then, they applied thinning technique to extract proper edges. The proposed technique is applied to a large database of synthetic and color images, and the results are found better in comparison to other edge detecting algorithms.

III. STEPS INVOLVED IN THE PROPOSED APPROACH

The steps involved in the proposed algorithm are described below:

[1] *Input RGB Color Image.*

[2] *RGB to HSV Conversion.*

[3] *Extract the V-Channel of the HSV Converted Image.*

[4] *Employ Multidirectional Sobel Filter to the Extracted V-Channel for detecting the edges.*

[5] *The old V-channel (obtained at step 3) has been replaced by the V-Channel obtained at step 4.*

[6] *HSV image at step 5 has been converted back to RGB color space to obtain the final edge detected image of the original color image.*

The above stages can be represented through flow chart as follows:

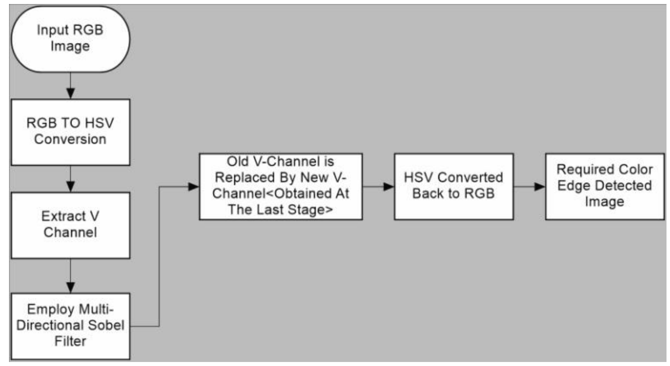


Figure 1: Flowchart of the Proposed Approach

IV. MULTIDIRECTIONAL SOBEL EDGE DETECTOR

Sobel operator is a gradient-based edge detection technique [13]. It is a discrete differentiation operator which computes an approximation of the gradient of the image intensity function. In the case of classical Sobel operator[13], it involves two kernels for each image Gx and G_y, where, G_x is the gradient estimation in the x-direction while G_y the gradient estimation in the y-direction.

The absolute gradient magnitude can be calculated with the following equation:

$$G = \sqrt{G_x^{\,2} + G_y^{\,2}}$$

But often this equation is made an approximation to:

$$|G| = |G_x| + |G_y|$$

The directions θ of the gradient can be obtained as:

$$\theta = a\tan\left(G_y / G_x\right)$$

Sobel operator is the frequently chosen gradient based operator for edge detection because of its capacity of detecting edges also for images containing redundant information like noise. The reason behind is that here every image is differentially separated by two rows and columns, thereby enhancing the edge elements on both sides, which in turn results in a very bright and thick look of the edges[9]. However, classical Sobel operator is limited to only two directions, i.e., horizontal and vertical [9]. The performance of this operator can further be increased if multiple directions are considered for gradient estimation [14] [15] [16]. So, in this paper, we have made an effort to bring an improved multi-directional Sobel filter by considering all the possible the eight directions are considered for gradient estimation [9]. These directions can be specified by considering corresponding angles as 45 °, 90°, 135 °, 180 °, 225 °, 270 °, 315 °, and 360 °.

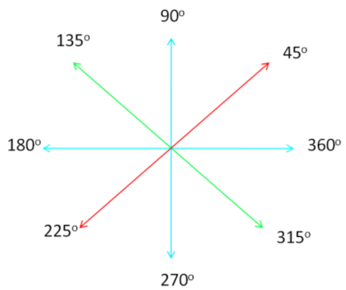


Figure 2: Gradient Estimation in 8 Directions

A general template of 3x3 image mask is say [9]:

$$\begin{pmatrix} p_{11} & p_{12} & p_{13} \\ p_{21} & p & p_{23} \\ p_{31} & p_{32} & p_{33} \end{pmatrix}$$

Where, p is the concerned pixel. The parameters used for the multi-directional Sobel operator are [9][17]:

$$G_H = \begin{pmatrix} a & b & a \\ 0 & 0 & 0 \\ -a & -b & -a \end{pmatrix} \quad , \quad G_v = \begin{pmatrix} -a & 0 & a \\ -b & 0 & b \\ -a & 0 & a \end{pmatrix} \quad ,$$

$$G_{dl} = \begin{pmatrix} 0 & a & b \\ -a & 0 & a \\ -b & -a & 0 \end{pmatrix} \text{ and } G_{dr} = \begin{pmatrix} b & a & 0 \\ a & 0 & -a \\ 0 & -a & -b \end{pmatrix}$$

V. HSV COLOR SPACE

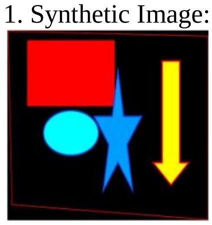
It requires a mathematical model to organize different colors of an image. This abstract model is known as color space. Color space represents different color attributes with respect to three or more components that help to learn accurately how each color spectrum looks like [18][19][20][21]. There exist different types of color space with respect to different applications. In our case, we have adopted HSV color space for our proposed approach. HSV color space has a big advantage that it organizes any color image in the same way that our human eyes can perceive. Also, this color space is more suitable for our task of detecting edges in color image as here we have one channel, V-channel particularly devoted for representing luminance of an image. The luminance channel stores the brightness intensity values, and we have employed Multidirectional Sobel Operator on this channel to mark the edges. In this way, we are not affecting the hue values and hence this helps to eliminate the color misclassification problem of color edges in an image. A detail on HSV color space can be found in [21]. To convert an RGB image into HSV one, we have the following pseudo code [20]:

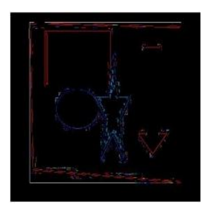
```
max = MAX(R,G,B);
min = MIN(R,G,B);
V = max/G_max ;                //Brightness Value
if (max ≠ 0) then S = (max − min)/min        //Saturation Value
else  S = 0
      H = undefined
end{if};
if (S > 0) then
      C_R = (max − R)/(max − min);
      C_G = (max − G)/(max − min);
      C_B = (max − B)/(max − min);
if (max == R) then if (min == G) then H = 5 + C_B      //Color Between Magenta and Yellow
              else H = 1 − C_G
elseif (max == G) then if (min == B) then H = 1 + C_R   //ColorBetween Yellow and Cyan
              else H = 3 − C_B
elseif (min == R) then H = 3 + C_G                     //ColorBetween Cyan and Magenta
              else H = 5 − C_R
end{if}
if (H < 6) then H = H • 60
          else H = 0
end{if}
```

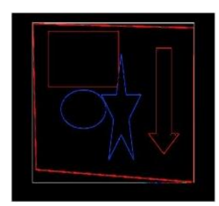
VI. EXPERIMENTAL SECTION

The proposed algorithm has been implemented in Matlab. The computer used has an i5 processor with 64-bit operating system. The proposed algorithm is first tested with synthetic image. And the real color images used in the experiments are collected from Berkeley Image Segmentation Dataset [22], Earth Science World Image Bank [23], Standard Lena Image [24] and Matlab Demo Image. We have compared our result with those obtained from the recent state of the algorithms: the one proposed by G.Xin[25] and H. Rami[8]. The results are presented below:

1. Synthetic Image:


(a)


(b)


(c)

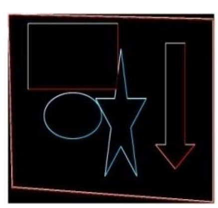
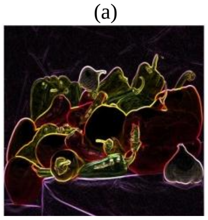

(d)

Figure 3: (a)Original Image;(b)Output Obtained With H.Rami's Method;(c)Output Obtained With G.Xin's Method; (d) Output Obtained With Our Proposed Method.

2. Pepper's Image:

(a) (b) (c)



(d)

Figure 4: (a)Original Image;(b)Output Obtained With H.Rami's Method;(c)Output Obtained With G.Xin's Method; (d) Output Obtained With Our Proposed Method.

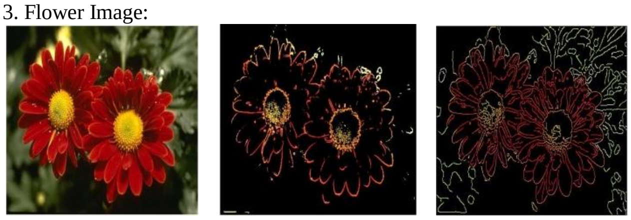
3. Lena Image:

(a) (b) (c)

(d)

Figure 5: (a)Original Image;(b)Output Obtained With H.Rami's Method;(c)Output Obtained With G.Xin's Method; (d) Output Obtained With Our Proposed Method.

3. Flower Image:

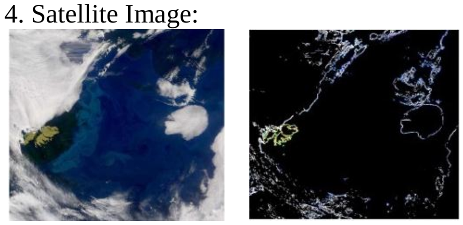


(a) (b) (c)

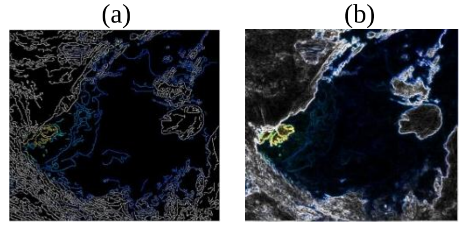
(d)

Figure 6: (a)Original Image;(b)Output Obtained With H.Rami's Method;(c)Output Obtained With G.Xin's Method; (d) Output Obtained With Our Proposed Method.

4. Satellite Image:



(a) (b)



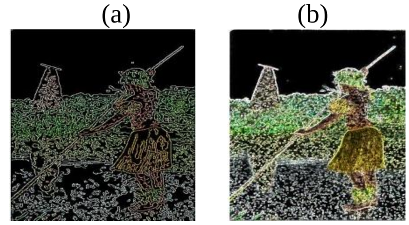
(c) (d)

Figure 7: (a)Original Image;(b)Output Obtained With H.Rami's Method;(c)Output Obtained With G.Xin's Method; (d) Output Obtained With Our Proposed Method.

5. Noisy Image:

In the boatman image, salt & pepper noise of density 0.04 is added. After that, this noisy image has been undergone edge detection with our proposed approach, G.Xin[25] and H. Rami[8] techniques. The results obtained are:

(a) (b) (c)



(d) (e)

Figure 8: (a)Original Image;(b)Noisy Version of The Original Image(c)Output Obtained With H.Rami's Method;(d)Output Obtained With G.Xin's Method; (e) Output Obtained With Our Proposed Method.

From the above experimental results, it is clear that our proposed method succeeds to bring better edge detection than the state of the art methods H.Rami[8] and G.Xin[25]. Also, even in the existent of noise(see fig(8)), the proposed method stands robust by showing comparatively better results than the other methods.

VII. CONCLUSION AND FUTURE WORK

In this paper, a novel approach for color image edge detection technique based on multi-directional Sobel filter is proposed. The proposed technique has been applied on the synthetic image as well as real life color images obtained from various standard image databases. The results obtained are stable and free of redundant edges. The color edges are uniquely visible with its distinct color and a good thickness. The ROIs are clearly visible and hence properly localized due to the better quality of the detected edges. Also, in the presence of noise, the proposed method succeeds to produce better performance in comparison to the other state of the art algorithms. So, overall, the proposed method is producing an excel performance in case of color edge detection and hence establishes a novel framework for the same. The only disadvantage with this approach is its relatively high complexity involved in the execution of multi-directional Sobel filter. In our future work, this will be our major concern to lessen the time complexity involved. Also, in near future, the proposed work will be extended to medical image dataset for analysis of concerned targeted pattern through color edge detection.

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Authors Profile

Vol.4(2), *Mr. Dibya Jyoti Bora* is a researcher in the field of Image Processing and Machine Learning, particularly Cluster Analysis and Image Segmentation. His research works solve many problems related to Color Image Segmentation process. He has contributed more than 12 research papers as his 1st authorship in international journals and national and international conferences including IEEE. Most of them are highly cited and applied in different technical fields including agriculture and medical imaging areas. As per academic details, he got distinction in his Graduation with honors in Mathematics, University 1st rank in PG(Information Technology) and currently pursuing Ph.D. in Computer Science(Thesis is at the submission stage). He has qualified several lectureship ability tests including GATE CS/IT two times, UGC SET in Computer Science and Applications. He has 4 years of teaching experience in university PG level. He is currently teaching in the Department of Computer Science And Applications, Barkatullah University, Bhopal for PG students of CS and IT. Previously, he taught in the Computer Application Department, NEHU. He has two certifications in Image Processing Specialization, one from Duke University and the other from Northwestern University.