YCoCg color Image Edge detection

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Abstract: Edges are prominent features in images and their analysis and detection are an essential goal in computer vision and image processing. Indeed, identifying and localizing edges are a low level task in a variety of applications such as 3-D reconstruction, shape recognition, image compression, enhancement, and restoration. This paper presents a comparative study on different approaches to edge detection of colour images. The approaches are based on transforming the RGB image to YUV and YCoCg and back to RGB colour model. Edges are detected by Laplacian operator and Gradient Operator. The results show that the colour models can be adopted based on the industry that colours are to be used.

I. INTRODUCTION

Edge detection is an important image processing tool that is used as a fundamental pre-processing step in many image processing applications. Edges map have a significant role in application such as image categorization, image registration, feature extraction, and pattern recognition. An edge detector can be defined as a mathematical operator that responds to the spatial change and discontinuities in gray levels of pixels set in an image [1].Each industry that uses color employs the most suitable color model. For example, the RGB color model is used in computer graphics, YUV or YCbCr are used in video systems, PhotoYCC* is used in PhotoCD* production and so on. Transferring color information from one industry to another requires transformation from one set of values to another. Intel IPP provides a wide number of functions to convert different color spaces to RGB and vice versa.

Several approaches of different complexity already exist to edge detection in color images. Nevertheless, the question remains of how different are the results when employing computational costly techniques instead of simple ones. Edge detection is an important process in low level image processing. Since color images provide more information than gray value images, more detailed edge information is expected from color edge detection that becomes vital for edge based image segmentation or edge-based stereo matching [2]. It has to be pointed out that no edges will be detected in gray value images when neighboring objects have different hues but equal intensities. Such objects can not be distinguished in gray value images. They are treated like one big object in the scene. This is not significant if obstacle avoidance is the task of the vision system. Opposed to this, the capability of distinguishing between one big object and two (or several) small objects may become crucial for the task of object grasping or even in 2-D image segmentation. Additionally, The common shortcomings of the RGB image edge detection arithmetic are the low speed and the color losses after the each component of the image is processed. Thus, an approach to color edge detection is proposed based on changing the domain of the edge detection. The RGB image is transformed to YUV and YCoCg that provide high quality results.

II. DIFFERENT COLOUR SPACES

A. YUV or YCbCr Color Model

YCbCr color space is used for component digital video is a scaled and offset version of the YUV color space. The YUV color model is the basic color model used in analogue color TV broadcasting. Initially YUV is the re-coding of RGB for transmission efficiency (minimizing bandwidth) and for downward compatibility with black-and white television. The YUV color space is "derived" from the RGB space. It comprises the *luminance* (Y) and two color difference (U, V) components. The luminance can be computed as a weighted sum of red, green and blue components; the color difference, or *chrominance*, components are formed by subtracting luminance from blue and from red. The principal advantage of the YUV model in image processing is decoupling of luminance and color information. The importance of this decoupling is that the luminance component of an image can be processed without affecting its color component. For example, the histogram equalization of the color image in the YUV format may be performed simply by applying histogram equalization to its Y component. There are many combinations of YUV values from nominal ranges that result in invalid RGB values, because the possible RGB colors occupy only part of the YUV space limited by these ranges. YUV space that corresponds to the RGB color cube The YCbCr color

space is used for component digital video is a scaled and offset version of the YUV color space. The position of the block of RGB-representable colors in the YCbCr space is shown in Figure2.1 RGB Colors Cube in the YCbCr Color Space.

B.Conversion Between RGB and YCbCr Color Space

Y' = 0.257*R' + 0.504*G' + 0.098*B' + 16
Cb' = -0.148*R' - 0.291*G' + 0.439*B' + 128
Cr' = 0.439*R' - 0.368*G' - 0.071*B' + 128
R' = 1.164*(Y'-16) + 1.596*(Cr'-128)
G' = 1.164*(Y'-16) - 0.813*(Cr'-128) - 0.392*(Cb'-128)
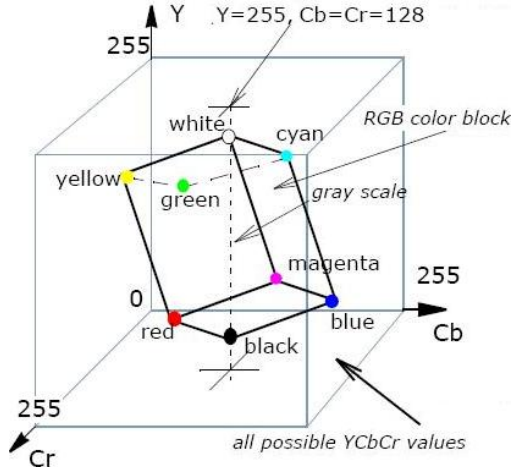*B' = 1.164*(Y'-16) + 2.017*(Cb'-128)*

Figure2.1 RGB Colors Cube in the YCbCr Space

C. YCoCg Color Model

This color space was invented to use similar encoding techniques as YCbCr but with frames in RGB color space. It is possible to losslessly transform from RGB to YCoCg when using 2 more bits for YCoCg representation than for RGB. E.g., it is possible to losslessly transform a pixel from a 30-bit RGB frame into a pixel in a 32-bit YCoCg 4:4:4 frame and back. This assumes that each R, G, and B component will have 10 bits of information which Y will have 10 bits and Co and Cg will each have 11 bits.Sometimes this colorspace is called YCoCg-R because of the lossless reversible transformation.

D. Conversion Between RGB and YCoCg Color Space

Y = ((R + 2*G + B)+ 2)/4
Co = ((R - B) + 1))/2
Cg = ((- R + 2*G - B) + 2)/4
R = Y + Co - Cg
G = Y + Cg
B = Y - Co – Cg

III. EDGE DETECTION OPERATORS

A. Laplace operator

The *Laplace operator* is defined as the dot product (inner product) of two gradient vector operators:

$$\Delta \stackrel{\triangle}{=} \nabla^2 \stackrel{\triangle}{=} \nabla \cdot \nabla = (\frac{\partial}{\partial x}\vec{i} + \frac{\partial}{\partial y}\vec{j}) \cdot (\frac{\partial}{\partial x}\vec{i} + \frac{\partial}{\partial y}\vec{j}) = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}$$

When applied *f(x,y)*to , this operator produces a scalar function:

$$\triangle f(x,y) = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$$

In discrete case, the second order differentiation becomes second order difference. In 1D case, if the first order difference is defined as

$$\nabla f[n] = f'[n] = D_n[f[n]] = f[n+1] - f[n]$$

then the second order difference is

$\triangle f[n]$:

$$\nabla^2 f[n] = f''[n] = D_n^2[f[n]] = f'[n] - f'[n-1]$$

$$(f[n+1] - f[n]) - (f[n] - f[n-1]) = f[n+1] - 2f[n] + f[n-1]$$

f''[n] is so defined that it is symmetric to the center element *f[n]* . The Laplace operation can be carried out by 1D convolution with a kernel [1,-2,1].

In 2D case, Laplace operator is the sum of two second order differences in both dimensions:

$$
\begin{aligned}
D_m^2[f[m,n]] + D_n^2[f[m,n]] &= f[m+1,n] - 2f[m,n] \\
&+ f[m-1,n] + f[m,n+1] \\
&- 2f[m,n] + f[m,n-1] \\
&= f[m+1,n] + f[m-1,n] + f[m,n+1] \\
&+ f[m,n-1] - 4f[m,n]
\end{aligned}
$$

This operation can be carried out by 2D convolution kernel:

$$
\begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix}
\qquad
\begin{bmatrix} 1 & 1 & 1 \\ 1 & -8 & 1 \\ 1 & 1 & 1 \end{bmatrix}
$$

B. Sobel operator

The Sobel operator performs a 2-D spatial gradient measurement on an image. Typically it is used to find the approximate absolute gradient magnitude at each point in an input grayscale image. The Sobel edge detector uses a pair of 3x3 convolution masks, one estimating the gradient in the x-direction (columns) and the other estimating the gradient in the y-direction (rows). A convolution mask is usually much smaller than the actual image. As a result, the mask is slid over the

image, manipulating a square of pixels at a time. The actual Sobel masks are shown below:

-1	0	+1
-2	0	+2
-1	0	+1

+1	+2	+1
0	0	0
-1	-2	-1

Gx   Gy

The magnitude of the gradient is then calculated using the formula:

$$|G| = \sqrt{Gx^2 + Gy^2}$$

An approximate magnitude can be calculated using:
|G| = |Gx| + |Gy|

IV.   EDGE DETECTION IN YCOCG COLOUR SPACE

The edge detection Algorithms for color images in RGB color space statistics shows that the common shortcomings of the RGB image edge detection arithmetic are the low speed and the color losses after the each component processing and about 90% edge information in the color image is the same as in the gray image, that is to say, about 10% edge information in the color image has not been detected, so it is essential that the problem of color image edge detection can be optimized further in YCbCr colour space.

A. The proposed algorithm using Laplacian operator can be explained in seven steps

I.   The RGB image is sub divided into R,G and B layers of the image.
II.   A 3X3 Laplacian mask is convolved with the R component of the image.
III.   The edge detected R and the G,B layers of the image are concatenated to obtain edge detected image
IV.   R,G and B values of the image are Transformed into its YCoCg intensity values using the conversion formula.
V.   A 3X3 Laplacian mask is convolved with the Y component of the image.
VI.   The edge detected Y and the Cb,Cr layers of the image are concatenated to obtain edge detected image
VII.   The edge detected YCbCr image is transformed into RGB colour space for further computer processing

B. The proposed algorithm using Sobel operator can be explained in seven steps

I. The RGB image is sub divided into respective R,G and B layers of the image.
II. A 3X3 Sobel mask is convolved with the R component of the image.
III. The edge detected R and the G,B layers of the image are concatenated to obtain edge detected image

IV. R,G and B values of the image are Transformed into its YCoCg intensity values using the conversion formula.
V. A 3X3 Laplacian mask is convolved with the Y component of the image.
VI. The edge detected Y and the Co,Cg layers of the image are concatenated to obtain edge detected image.
VII. The edge detected YCoCg image is transformed into RGB colour space for further computer processing.

V. EDGE DETECTION IN YCOCG COLOUR SPACE

The YCoCg primaries are hypothetical because they do not correspond to any real light wavelengths. The Y primary is intentionally defined to match closely to luminance, while Co and Cg primaries give color information. The YCoCg color model was developed to increase the effectiveness of the image compression .This color model comprises the luminance (Y) and two color difference components (Co - offset orange, Cg - offset green).

A. proposed algorithm using Laplacian operator can be explained in seven steps

I.   The RGB image is sub divided into R,G and B layers of the image.
II.   A 3X3 Laplacian mask is convolved with the R component of the image.
III.   The edge detected R and the G,B layers of the image are concatenated to obtain edge detected image
IV.   R,G and B values of the image are Transformed into its YCoCg intensity values using the conversion formula.
V.   A 3X3 Laplacian mask is convolved with the Y component of the image.
VI.   The edge detected Y and the Co,Cg layers of the image are concatenated to obtain edge detected image
VII.   The edge detected YCoCg image is transformed into RGB colour space for further computer processing.

B. The proposed algorithm using Sobel operator can be explained in seven steps

I. The RGB image is sub divided into respective R,G and B layers of the image.
II. A 3X3 Sobel mask is convolved with the R component of the image.
III.   The edge detected R and the G,B layers of the image are concatenated to obtain edge detected image
IV.   R,G and B values of the image are Transformed into its YCoCg intensity values using the conversion formula.
V.   A 3X3 Laplacian mask is convolved with the Y component of the image.

VI.   The edge detected Y and the Co,Cg layers of the image are concatenated to obtain edge detected image.

VII.   The edge detected YCoCg image is transformed into RGB colour space for further computer processing.

VI.   EXPERIMENTAL RESULTS

Sobel operator and Laplacian operators are used detect Edges on different application specific Satellite, Biomedical and general colour images, due to the space consideration Laplacian operator edge detection on Fruits image is presented in this paper. Figure 6.1, 6.2, 6.3 and 6.4 are the RGB layers of the image, Sobel and Laplacian edge detected images, Laplacian YCbCr edge detected image and Laplacian YCoCg edge detected image
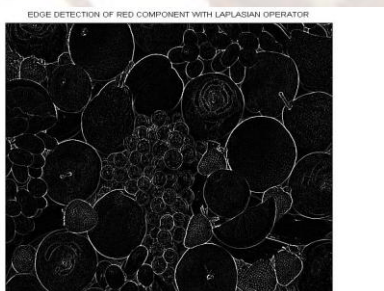

Fig6.1.RGB image

Fig6.2.Gradient red edge detection

Fig6.3.Laplacian red edge detection
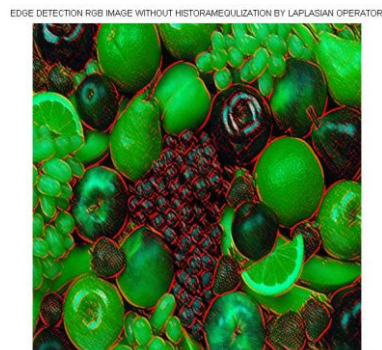

Fig6.4.Laplacian red edge detection of RGB with out hist equalization
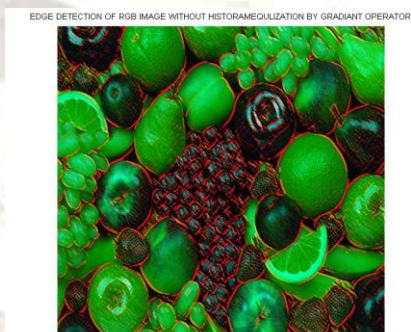

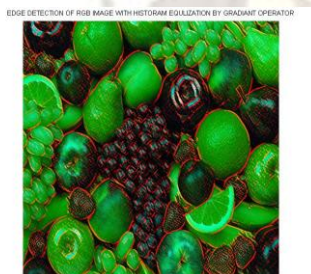**Fig6.5.RGB image edge detection with out hist equalization**

Fig6.6.RGB image edge detection with hist equalization

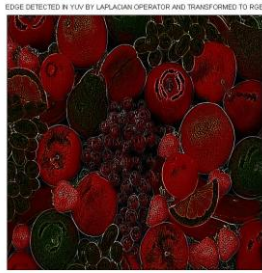**Fig6.7.RGB-YUV-RGB transform check**

Fig6.8.Edge detection of y comp in yuv with laplacian and conv to rgb

Fig6.9.YCoCg image

Fig6.10.Gradient edge detection in YCoCg domain and conversion to rgb

VII.   CONCLUSIONS

The proposed approach has a potential for various applications to detect edges of specific categories of images, such as surveillance videos/images, biomedical images and satellite images for significant role in applications such as image categorization, image registration, feature extraction, and pattern recognition and based on the specific category of images the domain may be choosen such as for Computer graphics RGB, The YCbCr color space is used for component digital video and YCoCg space completely device-independent colour space is needed.

VIII.   FUTURE SCOPE

Several edge detection operators can be used and to obtain better edges of the images histogram equalization and adaptive histogram equalizations can be utilized further morphological transforms can be integrated for further better results.

IX.   REFERENCES

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