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MODIFIED COLOR BASED EDGE DETECTION OF REMOTE SENSING IMAGES USING FUZZY LOGIC

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Abstract: ***This research work has proposed a new color edge detection technique based on the combination of hue factor and principal component analysis to determine the problems with existing methods. First, a novel computational technique of hue transformation has been used to estimate the hue in the given image, and then image gradient operators also come in action to gain the accurate edges in hue factor. Also the edges of the original image will also be evaluated by using the fuzzy edge detector operator to draw the edges. Furthermore, whole object edges has been acquired by using the edge based fusion of the hue component, first principal component and Edge detection using fuzzy templates for color images. The experimental result has shown that the proposed technique outperforms over the available techniques.***
Keywords: HUE, HSV, PCA, Fuzzy edges, PFOM.

1. Introduction

Edges are vital confined changes of intensity in a digital image. There is a position of curled line up segments identified as edges. It is used in picture segmentation, information hiding, image coding and so on. Thus apply an edge detection algorithm to an image may simplify the whole data to be processed and may sort out information that perhaps will be regard as fewer related while preserving the main structural properties of an digital image. If edge detection step be successful, the corresponding task of interpret the information contents in original image may be simple.

1.1 PCA (principal component analysis)

Principal component analysis provides a powerful tool for data analysis and pattern recognition which is used in image processing as a technique for data dimension reduction or their decorrelation of variables and data compression as well

[1]. Principal component analysis is appropriate when you have obtained measures on a number of observed variables and wish to develop a smaller number of artificial variables (called principal components) that will account for most of the variance in the experimental variables. The PCA involve a mathematical formula that transforms a number of correlated variables into a number of uncorrelated variables called principal components. The PCA is used extensively in image classification and image compression. It computes a compact and optimal depiction of the data set. The first principal component gives description for as much of the variance in the data as possible. First principal component is taken along the way with the maximum variance. The second principal component points the direction of maximum variance as perpendicular to the first. The third principal component is taken along the direction of maximum variance in the subspace perpendicular to the first two and so on.

1.2 Edge Detection for Hue component

From color image to grey-scale image, leads to the result that a little edges are missed. In count, mostly of the missing edges result from hue changes. As a result, we can present a better edge detection depiction for color image once the problem of edge detection of hue component is solved.

1.3 Morphological Thinning

Thinning is a morphological process that is used to eliminate chosen foreground pixels from binary images. It is generally used to tidy up the output of edge detectors by reducing all lines to particular pixel thickness. This method is employed after the image has been filtered for noise (using median, Gaussian filter etc.), the edge operator has been applied to detect the edges and after the edges have been smoothed using an appropriate threshold value. This removes all the useless points and if applied carefully, results in one pixel thick edge elements. Thinning is usually only applied to binary images, and produces an additional binary image as output. Sharp and thin edges lead to greater efficiency in object recognition. To eliminate unnecessary points on the edges in an image.

1.4 True color

True color supports 24-bit for three RGB color. It provides a technique of represent and store graphical-image information in an RGB color space such that a very huge number of colors, shades, and hues can be displayed in a digital image, such as in high-class photographic images or complex graphics. Generally, true color is defined to mean at least 256 shades of red, green, and blue.

1.5 Fuzzy Based Edge detector

Fuzzy logic: Fuzzy means not clear, different, or precise, blurred. A form of facts demonstration suitable for designs that cannot be define correctly, but which depend upon their contexts called fuzzy logic.

Benefits of using Fuzzy logic-

(a) Fuzzy logic provides another way to characterize linguistic and subjective attributes of the real world in computing.

(b) it is capable to be applied to control systems and other applications in order to recover the efficiency and simplicity of the design process.

2. Literature Survey

Lei and Fan (2013) [1] has proposed a novel color edge detection method based on the fusion of hue component and principal component analysis to solve the problems. First, a novel computational method of hue difference is defined, and then it is applied to classical gradient operators to obtain accurate edges for hue component. Moreover, complete object edges can be obtained by using the edge fusion of the first principal component and hue component of color image with low-computational complexity. Franchini et al. (2013) [2] has proposed a hardware implementation of an edge detection method for color images that exploits the definition of geometric product of vectors given in the Clifford algebra framework to extend the convolution operator and the Fourier transform to vector fields. The proposed architecture has been prototyped on the Celoxica Field Programmable Gate Array (FPGA) board. Wang and Yan (2012) [3] has presented a new edge detection approach based on vector morphological operators in color image processing. A new vector ordering in RGB color space has proposed. And then by analyzing the characteristics of the noise contaminating image, vector morphological operators has proposed and these operators are applied in color edge detection. A novel edge detection method based color morphological gradient operators for color image processing in RGB color space. The new ideal is noise pixels judgment and removing, which can be used to define color morphological erosion and dilation. Xu et al. (2012) [4] has proposed a novel approach of edge detection for color image in order to efficiently preserve edge in noise appearance. Firstly, multi-structure elements are designed in order to construct morphological gradient operators with performance of noise latter is consistent with human vision perception. Xin and Ki (2012) [5] has proposed an improved Canny algorithm to detect edges in color image. Algorithm is composed of the following steps: quaternion weighted average filter, vector Sobel gradient computation, non-maxima suppression based on interpolation, edge detection and connection. Algorithm is also applied to deal with color images of transmission line icing. The results show that our algorithm is still better than the gray image processing methods. XIAO et al. (2011) [6] has proposed a multi-scale edge detection algorithm which took soft threshold method to implement detail enhancement and noise reduction of the true color image. Firstly, obtaining the true color images at different scales through wavelet multi-scale edge detection algorithm, then based on the improved soft threshold filter function, selecting appropriate threshold of the obtained image edges to perform noise reduction while enhance the edge details of the reservation; and finally, carrying out the weighted 2-norm fusion of edges of different-scale-image. Dezert et al. (2011) [7] has presented an algorithm is based on the fusion of local edge detectors results expressed into basic belief assignments thanks to a flexible modeling, and the proportional conflict redistribution rule developed InDSmT framework. The purpose of DSmT is to overcome the limitations of DST mainly by proposing new underlying models for the frames of discernment in order to fit better with the nature of real problems, and proposing new efficient combination and conditioning rules. Gao and Zhau (2010) [8] has proposed a new mathematical methods QFD, and describe its geometric meaning and physical meaning and apply QFD to digital image processing. This method is appropriate for constructing a local boundary model. A new concept: quaternion fractional differential (QFD), and apply it to edge detection of color image. This method is called edge detection based on QFD. Chen et al. (2010) [9] to improve the efficiency and the performance of the color edge detection, a novel color edge detection algorithm has proposed. An improved Kuwahara filter is used to smooth the original image first. After edge detection with each channel independently in RGB color space, an adaptive threshold selection method is applied to predict the optimum threshold value and an edge thinning algorithm is used to extract accurate edge. Edge detection is an essential tool in image processing and computer vision. Jordan et al. (2011) [10] has proposed edge detection in multispectral images based on the self-organizing map (SOM) concept. To generate a global ordering of spectral vectors. With a global ordering, a one-to-one correspondence between pixel values and scalars is guaranteed. The edge probability is only determined by the adjacent pixels. This method omits linearization and uses the SOM more efficiently for edge detection while also retaining greater flexibility. Singh et al. (2013) [11] has proposed architecture uses only one processing element for computing gradients for all three R, G, and B color components and aims at reducing the FPGA resources usages. The FPGA resource usage is reduced more than 35% as compared to standard implementation which uses three gradient computation blocks. Somasundaram et al. (2012) [12] has proposed a novel edge detection method based on 32 fuzzy rules. Edge detection is one of the pre-segmentation processes of MRI head scans. It detects edges in a better way than the traditional Canny edge detector and Sobel edge detection operator and thus takes less time for edge detections. It produces sharp and clear edges that can be used for segmenting brain portions in MRI of human head scans. Jie and Ning (2012) [13] has proposed an adaptive threshold edge detection which applies the bilateral filtering it uses OTSU, which is based on gradient magnitude to maximize the reparability of the resultant classes, to determine the low and high thresholds of the canny operator. Finally, the edge detection and connection has performed. Firstly, this algorithm applies bilateral filtering to smooth the image, which not only has suppressed the noise of the image, but also has well preserved the edges. Secondly, OTSU is performed to adaptively determine the low and high thresholds.

3. Proposed method of Edge Detection

To attain the objective, step-by-step methodology is used in this dissertation. Subsequent are the different steps which are used to accomplish this work. Following are the various steps used to accomplish the objectives of the dissertation.

Step I. Input color image- Firstly, there is a given input image.

Step II. Apply RGB2HSV transform and edge detection- From color image to grey-scale image, leads to the outcome that a few edges are missed. In addition, mainly of the missing edges consequence from hue changes [1]. It preserves edges having same value in grey images. As a result, we can present a superior edge detection representation for color image once the problem of edge detection of hue component is solved. Thus apply an edge detection algorithm to an image may ease the total of data to be processed and may sort out information that possibly will be regard as less related while preserving the main structural properties of an digital image. If edge detection step be successful, the consequent task of interpreting the information contents in original image may be easy.

Step III. Apply image gradients-Then apply image gradients, Image gradients may be used to extract information from images. Gradient images are created from the original image. After gradient images have been computed, pixels with large gradient values become possible edge pixels. The pixels with the largest gradient values in the direction of the gradient become edge pixels, and edges may be traced in the direction perpendicular to the gradient direction. It is applied to get accurate edges for hue component. The gradient of an image is given by the formula:

$$\nabla f = \frac{\partial f}{\partial x}\hat{x} + \frac{\partial f}{\partial y}\hat{y} \qquad (1)$$

Where:

$\frac{\partial f}{\partial x}$ is the gradient in x- direction

$\frac{\partial f}{\partial y}$ is the gradient in y- direction

Step IV. Apply Principle Component Analysis and edge detection- Image color reduction, the three color components are condensed into one containing a main component of information. It makes complex object uncorrelated. The PCA involve a mathematical formula that transforms a number of correlated variables into a number of uncorrelated variables called principal components. The PCA is used extensively in image classification and image compression. It computes a compact and optimal depiction of the data set. The first principal component gives description for as much of the variance in the data as possible. First principal component is taken along the way with the maximum variance. The second principal component points the direction of maximum variance as perpendicular to the first. The third principal component is taken along the direction of maximum variance in the subspace perpendicular to the first two and so on. Thus apply an edge detection algorithm to an image may ease the total of data to be processed and may sort out information that possibly will be regard as less related while preserving the main structural properties of an digital image. If edge detection step be successful, the consequent task of interpreting the information contents in original image may be easy. To calculate the PCA:

$$C_{i_{ij}} = \frac{1}{N-1}\sum_{q=1}^{N} X_{q_{ij}} \cdot X_{q_{ij}} \qquad (2)$$

$C_{i_{ij}}$ (Diagonal) is the variance of variable i.

$C_{i_{ij}}$ (off-diagonal) is the covariance between i and j.

Step V. Apply fuzzy frication and evaluate edges based on fuzzy templates- The fuzzy edge detection is further used in edge detection as template matching. The fuzzy edge detection detects fine edges in an image. It preserves edges even in poor images having low intensity and gives best results.In the initial step, the average (T_1) of intensity values of all the pixels in the input image I is computed as:

$$T_1 = \frac{\sum_{i=0}^{N-1} x_i}{N} \qquad (3)$$

Where x, is the intensity of the pixel, N is the total number of pixels.

Step VI. Apply edge fusion- Fusion is the process of combine significant information from two or more images into a particular image. The consequential image will be more useful than any of the input images. By integrating all the edge detected images of hue, PCA and fuzzy frication and apply edge fusion to get fused image.

Step VII. Final edge detected image- The output is shown which represent the detected image.

4. Experimental results

As shown in the below given figures, we are comparing the results of various images. As results show that our proposed approach results are much better than exiting approaches. The developed approach is compared against some well-known methods available in literature. Here is some representation [1(a)-1(h)] of proposed algorithm to detect edges in a color image. Firstly input satellite image is shown below:-

Figure 1(a): Input Satellite Image

The figure 1(a) shows the input image which is captured from satellite to detect the fine edges which are not clear.

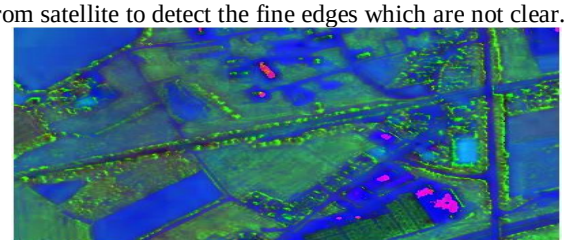

Figure 1(b): Hue Image

Figure 1(b) shows the hue image of given input image, the hue image describes the true color of an image. From color image to grey-scale image, leads to the outcome that a few edges are missed. In addition, mainly of the missing edges consequence from hue changes. Also the pixel values are same in grey scale images. So to detect missed edges we apply hue analysis to color image.

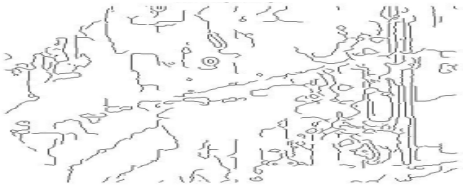

Figure 1(c): Hue Detected Edge Image

Figure 1(c) shows the hue detected edge image, we can present a superior edge detection representation for color image once the problem of edge detection of hue component is solved.

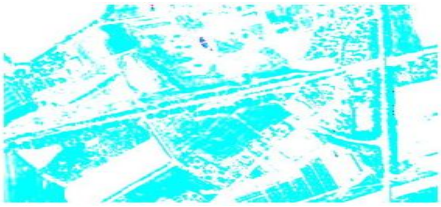

Figure 1(d): PCA Image

Figure 1(d) shows the PCA image of the given input image, the PCA describes the major component information of a part in an image. The three color components are condensed into one containing a main component of information. So to detect missed edges we apply PCA analysis to color image.

Figure 1(e): PCA Edge Detected Image

Figure 1(e) shows the PCA detected edge image, we can present a superior edge detection representation for color image once the problem of edge detection of PCA component is solved.

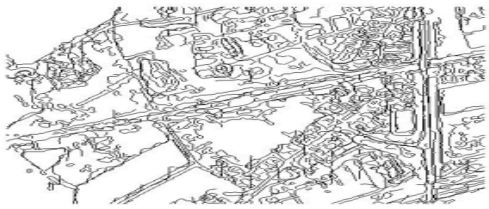

Figure 1(f): Fusion of Hue and PCA Edge Image

Fig. 1(f) shows fusion of hue and PCA edge image combine significant information from two or more images into a particular image and gets clearer results to detect edges in color image

Figure 1(g): Negative Selection Based Edge

Figure 1(g) shows negative selection based edge describes fuzzy templates. The fuzzy edge detection detects fine edges in an image. It preserves edges of an image even in low intensity images.

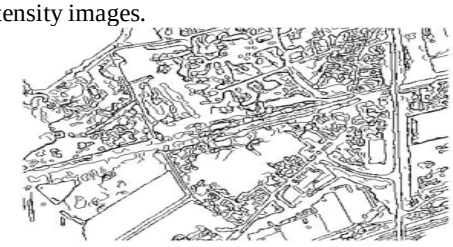

Figure 1(h): Final Edge Detected Image

Figure 1(h) gives the final result of edge detection in a color satellite image by fusion of hue component, PCA and fuzzy based edge detection.

5. Performance Analysis

This section contains the cross validation between existing and proposed techniques. Some well-known image performance parameters for digital images have been selected to prove that the performance of the proposed algorithm is quite better than the available methods.

Table1: Comparison of PFOM values of edge images by different methods

Images	Existing Pratt	Proposed Pratt
1.jpg	0.5993	0.6316
2.jpg	0.5385	0.6358
3.jpg	0.7214	0.6525
4.jpg	0.5480	0.6382
5.jpg	0.5838	0.5996
6.jpg	0.5578	0.6085
7.jpg	0.7398	0.6528
8.jpg	0.4662	0.6813
9.jpg	0.7498	0.6441
10.jpg	0.6807	0.7601

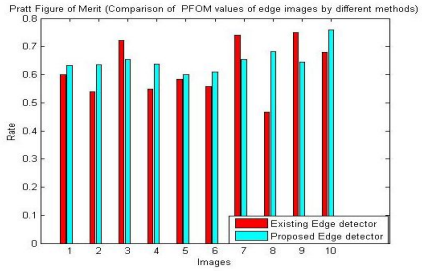

Figure 2: Figure of merit comparison

6. Conclusion & Future Scope

This paper has assessed the performance of fuzzy based color edge detector for remote sensing images. Remote sensing images has become very popular in many critical vision applications. The proposed technique has used color fuzzy based edge detectors in the HSV color domain. The use of true color along with fuzzy set theory has improved the accuracy of the proposed technique. The proposed technique has been designed and implemented using MATLAB tool with the help of image processing toolbox. The performance analysis has shown that the proposed technique outperforms over the available techniques. Only

remote sensing images has been considered in this work so in near future some other kind of images will also be considered.

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