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Dark image enhancement through channel division using spectral decomposition method

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Abstract:
Principle objective of image enhancement is to process an image so that result is more suitable than original image for specific application. Digital image enhancement techniques provide a multitude of choices for improving visual quality of an image. Artifacts, over enhancement and unnatural effects are produced by current contrast enhancement algorithms. The Content aware algorithm enhances the image by producing ad hoc transformation for each image by selecting particular content of an image which has to be processed. In order to produce better result of an image morphological method is introduced in this paper. To implement the proposed algorithm image is first transformed in to HSV color space using channel division method and background color of an image is estimated. After estimating the background color is subtracted from the original image to increase the image contrast. Threshold value of an image is calculated to identify the object which has to be enhanced. It analyzes the contrast of image in boundary and textured region and group the information in common characteristics. Results shows that combining these methods can automatically process wide range of images without introducing artifacts, which is an improvement over many existing methods.

Keywords— Image enhancement, Channel division, Morphological processing, Content Aware.

I. INTRODUCTION

The goal of image enhancement is to process an image so that the outcome is more suitable than original image. The technique not only improves the visual interpretability for human viewers but also increases the acuity of information contained within the image. Transformation of one image to another is called image enhancement which look and feel of an image for machine analysis or visual perception of human beings. Taking a picture in excessively bright or dark environment makes the captured image less contrasted. Several algorithms has been proposed to overcome this problem. One of the most common approach is histogram equalization (HE) [1]. Histogram equalization is a technique to obtain the uniform histogram for output images. It flattens the histogram and stretches the dynamic range of gray levels or in other words histogram equalization maps the input image intensity values over the range (0 to 255). This method enhances the contrast by distributing the cumulative density function (CDF) across entire dynamic range. It does not consider boundaries and creates artifacts in smooth region. It is restricted in real time applications because of its large computation and storage also degrades the image quality. Contrast stretching algorithm and their adaptive versions can produce good results in dark images however they produce no noticeable improvement over the image. Another method is the multi scale retinex algorithm which is fast version of retinex algorithm which mainly focus on dark-tone correction. This method has high computational complexity. The first step in content-based enhancement is the intensity pair distribution algorithm [2].This algorithm combines the global property of HE and local properties of AHE. Expansion and anti expansion forces are used while processing the image. Partially overlapped sub-block histogram equalization which is a derivation of local histogram and spend more expense for calculation complexity. Three new methods of transform histograms are logarithmic transform histogram mapping, logarithmic transform histogram shifting, and logarithmic transform histogram shaping. These methods needs less computational complicated techniques and are used only in spatial domain. The above mentioned methods significantly improves the contrast of an image but not much appropriate results in dark images.

Content aware algorithm selects particular content of an image to be processed by using channel division method. This algorithm builds an ad hoc transformation based on information extracted from an image. Content aware method analyzes the contrast in boundaries and in textured regions to produce ad-hoc transformation function. In general, current enhancement algorithm uses global information which results in creation of artifacts such as noise. These algorithms also require significant computation time due to their complexity. To overcome these problem the content of image is analyzed and determine the transformation function based on result .Content aware algorithm splits the original image in to regions by using channel division method. The splitted regions are merged by using weighting function to produce the enhanced image. Contrast is encoded by using contrast pair. In the proposed method, after dividing the original image in to HSV color space, Morphological method is used to calculate the intensity value and to produce better result than existing system. HSV stands for hue, saturation, value. It is the representation of point in RGB color model that attempt to describe perceptual color relationships more accurately than RGB. Hue corresponds to the common definition of color. Saturation refers to purity of color. Unlike previous methods the proposed method uses the ad hoc transformation based on the information from extracted images. Finally the results of transformations are mixed to boost the details in an image.

This paper is further organized as follows: Section II Related works Section III proposes the morphological method Section IV discuss about the algorithm description while experimental result in Section V and conclusion in Section VI.

II. RELATED WORKS

Histogram equalization is a technique for adjusting image intensities to enhance contrast.

Let f be a given image represented as a m_r by m_c matrix of integer pixel intensities ranging from o to L-1. L is the number of possible intensity values, often 256. Let p denote the normalized histogram of F with a bin for each possible intensity. So

$$P_n = \frac{\text{Number of pixels with intensity n}}{\text{Total number of pixels}} \quad n=0, 1,\ldots,L-1 \quad (1)$$

The histogram equalized image g will be defined by

$$g_{i,j} = floor((L-1)\sum_{n=0}^{f_{i,j}} p_n), \quad (2)$$

where floor() rounds down to the nearest integer. This is equivalent to transforming the pixel intensities, k, of F by the function.

$$T(k) = floor\left((L-1)\sum_{n=0}^{k} p_n\right). \quad (3)$$

The motivation of this transformation comes from thinking of the intensities of f and g as continuous random variables X, Y on [0, L-1] with Y defined by

$$Y = T(X) = (L-1)\int_0^x px(x)dx, \quad (4)$$

Where px is the probability density function of F. T is the cumulative distribution function of X multiplie4d by (L-1). Assume for simplicity that T is differentiable and invertible. It can be shown that Y defined on [0, L-1], namely that

$$\int_0^y py(z)dz = probability\ that\ 0 \le Y \le y \quad (5)$$

$$= probability\ that\ 0 \le X \le T^{-1}(y)$$

$$= \int_0^{x^{-1}(y)} p(x)^w \mathrm{dw}$$

$$\frac{d}{dy}(\int_0^y py^{(z)dz}) = py^y = px^{(T^{-1}}(y)\frac{d}{dy}(T^{-1}(y)).$$

which means,

$$py(y) = \frac{1}{L-1}.$$

The most popular approach is adaptive histogram equalization (AHE). AHE is based on localized data. However over-enhancement may happen and enhanced images may look unnatural. A method with a technique named brightness preserving bi-histogram equalization has been used for enhancing image. In this method image histogram was divided in to two sub parts based on mean value.

Then it independently applies HE in each sub histograms.

Dualistic sub-image histogram equalization method decomposes the image aiming at maximization of the output image. This method divides the input histogram based on median value. Recursive mean-separate histogram equalization (RMSHE) and minimum mean brightness error bi-histogram equalization (MMBBHE) are the extension of BBHE. However all these methods are capable of preserving the brightness only to a certain extent and brightness was controlled in the specific narrow range.

A luminance based multi scale retinex (LB-MSR) algorithm [4] is used to enhance the darker image. In this method color noise in the shadow region can be suppressed. Color saturation adjustment is produced. The color saturation degree can be automatically adjusted according to different types of images by compensating the original color saturation in each band. Luminance control is applied to prevent the unwanted luminance drop at the uniform luminance areas by automatically detecting the luminance drop and keeping the luminance up to certain level that is evaluated from the original image.

III. MORPHOLOGICAL METHOD

A.CHANNEL DIVISION METHOD

Channel division method is the process of merging the Local Contrast Indicator (LCI) i.e. grouping contrast pairs in to channels. To do this first the original image is split into regions of hue (H), saturation (S), value (V) using ad hoc transformation which is based on information from contrast of textured and boundary regions. Proposed algorithm is only applied to the value (V) region and at the same time (HS) [5] is maintained constant until merging. Contrast is coded by contrast pairs because of its inspiration so that it spreads over the dynamic range of intensities. Intensity channels are building blocks of region channel that can be used to control the interference and overlap of contrast pairs. In region channels, channels are grouped to simulate the human visual characteristics with a set of transformation functions which enhances the each image particular characteristics and merge the process results to reduce artifacts [6]. To adjust final transformation for enhancing the image this method uses channel division and mixture process. Contrast pairs are used to model the intensity difference between two pixels.

B. CONTRAST PAIR

Contrast pairs are used to model the intensity difference between two pixels i.e. contrast in the image. LCI function is used to model the contrast pairs interaction. A set of contrast pair is defined by

$$p(a,b) = \left\{ p_{r(a,b)}^{r(a',b')} \middle| a', b') \in N\ (a,b) \right\} \tag{6}$$

where $p_{r(a,b)}^{r(a',b')}$ is a contrast pair, N (a, b) contains 8 neighbors of (a, b), and I (a, b) are the intensities of the pixels (a, b) and (a', b'). Edge and smooth are two types of contrast pairs of each image [6]. Edges are found in the boundary and smooth in flat region. LCI function x is stated by,

$$x(i) = \sum a, b \sum p \in p_{e(a,b))}\, p(i) \tag{7}$$

where∈ is a constant, and (a, b) and (a', b') are pixel positions in the image. Contrast pair after computing the LCI is given by,

$$X(k) = \frac{\sum_{i=0}^{K} x(i)}{\sum_{i=0}^{N} x(I)} \tag{8}$$

Where X(k) is the position of force of integration X, k is the intensity index range $0 \leq k \leq N$, and N is the maximum number of intensity. Transformation function is stated by,

$$S(k) = \frac{I(k)+X(k)}{\max(I+X)}, 0 \leq k \leq N \tag{9}$$

C. PROPOSED ALGORITHM

The proposed method presented here uses Morphology method to identify the object which has to be enhanced. Morphological image processing is a collection of non-linear operations related to the shape or features in an image. Morphological techniques probe an image with a small shape or template called a structuring element. The structuring element is positioned at all possible locations in an image and it is compared with neighbourhood of pixels. Some operations test whether it fits within neighbourhood, while other test whether it hits or intersects the neighbourhood.When a structuring element is placed in a binary image, each of its pixels is associated with the corresponding pixel of the neighbourhood under the structuring element. In this sense, a morphological operation resembles a binary correlation. The operation is logical rather than arithmetic in nature. The structuring element is said to fit the image if, for each of its pixels that is set to 1, the corresponding image pixel is also 1.The structuring element is said to hit, an image if for any of its pixels that is set to 1, the corresponding image pixel is also 1.

The two principal morphological operations are dilation and erosion. Dilation allows the objects to expand, thus potentially filling in small holes and connecting disjoint objects. Erosion shrinks objects by etching away their boundaries. These operations are used for proper selection of the structuring element, which determines exactly how objects will be dilated or eroded. These two operations dilation and erosion can be combined into more complex sequences. The most useful of these morphological filtering are called opening and closing. Opening consists of an erosion followed by dilation and it is used to eliminate all pixels in regions that are too small to contain structuring element. Closing consists of dilation followed by erosion and it is used to fill in holes and small gaps.

The basic effect of the operator on a binary image is to gradually enlarge the boundaries of regions of foreground pixels i.e. white pixels, typically. Thus areas of foreground pixels grow in size while holes within those regions become smaller.The dilation operator takes two pieces of data as inputs. The first is the image which is to be dilated. The second is a usually small set of coordinate points known as a structuring element also known as a kernel. It is this structuring element that determines the precise effect of the dilation on the input image.

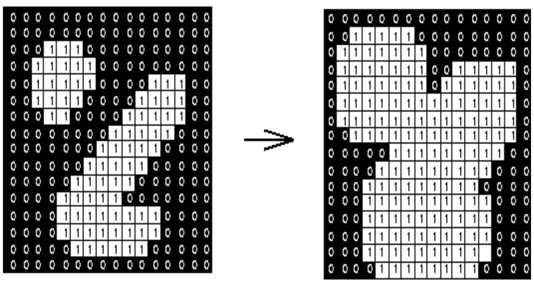

Fig 1.Dilation

Most implementations of this operator expect the input image to be binary, usually with foreground pixels at pixel value 255, and background pixels at pixel value 0. Such an image can often be produced from a gray scale image using threshold. It is important to check that the polarity of the input image is set up correctly for the dilation implementation being used.A larger structuring element produces a more extreme dilation effect, although usually very similar effects can be achieved by repeated dilations using a smaller but similarly shaped structuring element. With larger structuring elements, it is quite common to use an approximately disk shaped structuring element, as opposed to a square one.

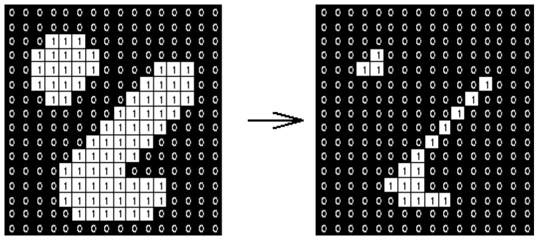

Fig 2.Erosion

Most implementations of this operator will expect the input image to be binary, usually with foreground pixels at intensity value 255, and background pixels at intensity value 0. Such an image can often be produced from a gray scale image using threshold. It is important to check that the polarity of the input image is set up correctly for the erosion implementation being used.

IV ALGORITHM DESCRIPTION

Detailed steps of the algorithm are as following:

Step I: Select a pixel in the input image.

Step II: To estimate the background of an image morphological opening method is used.

Step III: In this step the background approximation is made.

Step IV: After fixing the background, the background image
is subtracted from the original image.

Step V: After subtracting the threshold value is calculated to
identify the object.

Step VI: Display the enhanced image.

V. EXPERIMENTAL RESULT

In this section the performance of the proposed method is optimized.Enhancement errors in the HE results introduces the peaks in the luminance and contrast indices and keeps the structural index low in comparison to other methods. The below tabular column indicates the amount of percentage evaluates while comparing images by using different methods. In general the proposed method produces the better result by producing images with means closer to ideal images.

Fig 3(a) Input image Fig 3(b) Enhanced image

Darkness level	Method	WLS
SNR=10	Channel division	24.65
	PSNR	0.3949
SNR=15	Channel division	28.82
	PSNR	0.6194
SNR=20	Channel division	36.25
	PSNR	0.9645
SNR=25	Channel division	38.53
	PSNR	0.9804
Average execution time		3s

Fig 4.Similarity indices of different enhancement methods

V. CONCLUSION

Content aware enhancement algorithm with morphological method can improve images from a variety of different environments. This method improves the content of image thereby improving its enhancement capabilities and reduces the artifacts. The proposed method is robust because it adapts its transformation function to the contents of image.

This allows us to enhance some characteristics, such as the details in dark and bright regions, while preserving others such tones in smooth and flat regions. It has the tendency to avoid over enhancement problems by producing better results. It also increases the quality of output because it allows distinct enhancement for different parts of the image.

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