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Survey on Image Enhancement

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Abstract: - *The contrast enhancement method frequently play crucial role in image processing. Image enhancement is the task to process an image so that the result is more suitable than the original image for specific applications. The alteration usually requires interpretation and feedback from a human evaluator of the output resulting image. Image enhancement is to improve the image quality so that the resultant image is better than the original image for a specific application or set of objectives. The channel division technique enables operation on the content of the image and therefore content such as edges and other subtle information can easily be enhanced. This paper also presents a review of various methods for contrast enhancement. The channel division technique is based on the analysis of the content in several regions and create transformation function for separate region. This paper also present method which divides the image into sub image then perform enhancement. The major difference among the methods in this family is the criteria used to divide the input histogram. Brightness preserving Bi-Histogram Equalization (BBHE), weighted mixture of global and local transformation, sub block histogram equalization, recursively separated method are based on the split image in its sub images then perform enhancement. In image dependent brightness preserving method curvelet transform function used. Brightness preserving dynamic histogram equalization is an extension of histogram equalization.*

Index Terms – *Contrast enhancement, histogram equalization, channel division, bihistogram equalization, POSHE, curvelet transform, global transformation function, local transformation function, intensity pair.*

I. INTRODUCTION

The process of changing the pixels' intensity of the input image, so that the output image should looks better is term as image enhancement [1]. The purpose of image enhancement is to improve the image quality by changing pixels value such that the output image looks better than the input image. There are many image enhancement method have been proposed. The method which are based on content of the image is channel division technique [2]. Channel division method analyze the content of the text and boundary region and than by applying transformation function perform the enhancement. But this method suffer from one drawback ,it cannot recover information from shadow areas. Another method for enhancement is histogram equalization(HE). HE enhance the image by using cumulative transform function, this method simple but it can create artifacts in boundaries and text regions. So many method based on HE proposed[3]-[6]. The bi-histogram[3] equalization method divides the input image into two sub images based on the mean and then perform enhancement on each part separately , at last both parts are merged. But this method suffers from over enhancement problem. Sub block HE [4] used low pass filter to get nonoverlapped sub block HE function, whereby the histogram is equalized based on localized data. Yet, this method still produces unnatural effect and needs extra computation time for output scaling. Consequently another method have been developed to overcome the limitations of the all previous methods. Another enhancement method brightness preserving histogram equalization [5] which is based on curvelet transform function and histogram matching is .This method is not always allows good result

and unnatural image are still produced. Another popular method is weighted mixture [6], where the enhancement method is based on the weighting mixture of local and global transformation function based on mapping function. This method gives better increment in image enhancement. But still suffer the drawback of shifting mean value in local transformation. The method based on classification of image characteristics is adaptive image enhancement [7]. Another method is the dynamic histogram equalization for image contrast enhancement [8], which is an extension of HE that produce output image with mean intensity almost equal to mean intensity of the input image. The modified technique called brightness preserving dynamic fuzzy HE (BPDFHE) [9], uses fuzzy statistics of digital images for there representation and processing. In most cases the contrast improvement provided by BPDFHE is credibly more than that provided by BPDHE. Another complex methods is the multiscale retinex algorithm (MSR) [10], which is fast version of retinex algorithm [11].

II. CHANNEL DIVISION TECHNIQUE

Content-aware method that analyzes the contrast in the boundaries and in the texture regions to produce ad hoc transformation functions. Then separate the different characteristics of the image and then group them by simulating the human visual characteristics. Due to the independent treatment needed for the groups, we build specific functions for each group that will enhance its characteristics. Finally, the results of the groups' transformations are mixed adaptively to boost the details in the image. , the proposed algorithm builds an ad hoc transformation function based on information extracted from the image. To implement the proposed algorithm, first transform the image to the hue–saturation–value color space. Then, we apply the proposed algorithm to the image intensity (V component). After the enhancement, we use the hue (H) and saturation (S) components from the original image and merge them with the enhanced intensities to create the final image. This procedure maintains the color (HS) of the image while improving its intensity level (V). Contributions of the expansion and anti-expansion forces manually. In contrast, our method uses the channel division and mixture process to adjust the final transformation, which thereby enhances the image. Contrast—i.e., the intensity difference between two pixels—in the image through contrast pairs. The contrast pairs are constructed from the image using the eight neighbours of each pixel. The contrast pairs classify of each image into two classes: edge and smooth. The former is found in the boundaries and texture regions, while the latter is found in the flat regions. To classify the pairs, we take the intensity difference

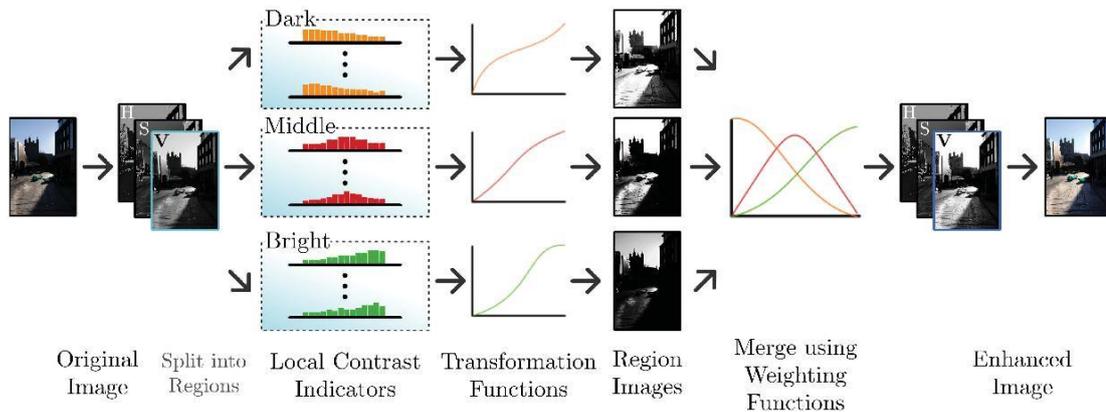


Fig. 1. Abstraction of the proposed method

between the pair's intensities. If it exceeds some defined threshold ϵ (in our experiments we used 10 intensity levels), then it is considered an edge contrast pair; otherwise it is considered a smooth contrast pair. To create transformation functions, then use the LCI from the contrast pairs. Only normalized LCI used to compute the transformation function. In addition we focus on the edge contrast pair because their accumulation determines the transformation needed to reveal the details of the image. The contrast pairs may belong to different intensity regions. Thus one accumulation of contrast pairs does not represent the intensity relations and may separate the intensities that should stay together. To overcome this problem, we group the contrast pairs into intensity channels. The creation of intensity channels enhances the contrast of one image's area without introducing artifacts.

Furthermore, the set of edge contrasts for the pixel (x,y) and intensity i, P_e^i is defined by

$$P_e^i(p) = \{P_{1(x,y)}^{I(x^l,y^l)} \varepsilon N(x,y) \wedge |I(x,y) - I(x^l,y^l)| \geq \varepsilon \wedge (i = I(x,y) \vee i = I(x^l,y^l))\} \tag{3}$$

The accumulations for each intensity channel LCI, F_i and T_i are projected by replacing f with f_i as follows:

$$F^i(K) = \frac{\sum_{j=0}^K f^i(j)}{\sum_{j=0}^N f^i(j)} \tag{4}$$

$$T(K) = \frac{I(K)+F^i(K)}{\max(I+F^i)}, 0 \leq K \leq N \tag{5}$$

Grouping the contrast pairs into intensity channels is not sufficient to produce the best enhancement, as there may be channels with similar properties. We propose to mix the channels with similar characteristics into region channels. Consequently, a region channel is a mix of intensity channels that share some characteristics. Hence, an image may have R different region channels that are defined by

$$T_r = \frac{\sum_{i=I_{min}^r}^{I_{max}^r} \tau^i}{I_{max}^r - I_{min}^r + 1}, 1 \leq r \leq R \tag{6}$$

Where T_r is the r^{th} region channel transformation, T^i is the transformation function for each intensity channel i and I_{min}^r, I_{max}^r are lower and upper bound (intensities) for the r^{th} region channel [the $(r - 1)^{th}$ and $(r + 1)^{th}$ channel may share there upper and lower bounds with the r th channel]. Finally, the enhanced image is a mixture the region channels, each channel has a different weighting function that emphasizes its characteristics. The final transformation function τ can be computed as

$$\tau(i) = \sum_{r=1}^R w_r(i) \cdot T_r(i) \tag{7}$$

Where w_r is the weighting function for the r th region channel, and $T_r(i)$ indicates the i th position in the r th region channel transformation function. Finally, the image is enhanced by

$$I(x,y) = (I(x,y)) \tag{8}$$

The proposed method could not recover information from the shadowed or dark areas of images that had near black intensities. Some parts of the image were still enhanced, but significant amount of near black intensities produced undesired effects in the high intensities

III. BRIGHTNESS PRESERVING BI-HISTOGRAM EQUALIZATION

Bi-histogram equalization based on the division of the input image into sub images based on the mean. One part has the sample less than mean and other part has sample greater than mean. The histogram equalization on the both image are applied separately and at last step both sub images are merged. Suppose a image with $(L-1)$ level is split into two sub images X_L and X_U based on mean m , then

$$X = X_L \cup X_U \tag{9}$$

Where

$$X_L = \{X(i,j) \mid X(i,j) \leq X_m, \forall X(i,j) \in X\} \tag{10}$$

$$X_U = \{X(i,j) \mid X(i,j) > X_m, \forall X(i,j) \in X\} \tag{11}$$

So from above equation it is clear that X_L is composed of $(X_1, X_2, X_3, \dots, X_m)$ and X_U is composed of $(X_{m+1}, X_{m+2}, X_{m+3}, \dots, X_{L-1})$.

Then probability density function of sub images are given below

$$P_L(X_K) = \frac{n_L^K}{n_L}, \text{ where } K = 0,1,2 \dots \dots, m \tag{12}$$

$$P_U(X_K) = \frac{n_U^K}{n_U}, \text{ where } K = 0,1,2 \dots \dots, m \tag{13}$$

In which n_L^K and n_U^K represents the no of X_K in X_L and X_U , and n_L and n_U are the total numbers of samples in input image.

The respective CDF for X_L and X_U are given below

$$C_L(x) = \sum_{j=0}^K P_L(X_j) \tag{14}$$

And
$$C_U(x) = \sum_{j=m+1}^{L-1} P_U(X_j) \tag{15}$$

Where $X_L = x$

Cdf is a transform function. Now the transform function exploiting the cdf.

$$f_L(x) = X_0 + (X_m - X_0) C_L(x) \tag{16}$$

$$\text{and } f_U(x) = X_{m+1} + (X_{L-1} - X_{m+1}) C_U(x) \tag{17}$$

The decomposed sub images are equalized independently based on above transform function and then resulting sub images are composed to form complete histogram. Suppose Y represent the output image then

$$Y = \{Y(i, j)\} \tag{18}$$

$$Y = f_L(X_L) \cup f_U \tag{19}$$

Although BHE increase the performance of HE but sometime this method suppresses the over enhancement problem. Unnatural images however still occur.

IV. SUB BLOCK HISTOGRAM EQUALIZATION

In this method a low pass filter type mask is used to get a nonoverlapped sub block histogram equalization function to produce the high contrast associated with local histogram equalization. The low pass filter type mask is realized by partially overlapped sub block histogram equalization(POSHE). Since with the proposed method, the sub block are much less overlapped the computation overhead is reduced by a factor of about 100 compare to that of local histogram equalization. The procedures of Poshe are given below:

1. Define an MXN sized output image array for MXN input image and set all value to zero.
2. Assign a $m \times n$ sub-block. For computational simplicity a subblock size is selected to be equal to the quotient of the input image size is divided by a multiple of 2. Assign the sub block origin using the input image origin.
3. Perform local histogram equalization for each sub block and the result are accumulator in the output image array.
4. Increase the horizontal coordinate of the sub block origin by the horizontal step size and repeat step 3. When the horizontal coordinate equals the horizontal input image size, increase the vertical coordinate of the sub block origin by the vertical step size and repeat horizontal POSHE. Repeat whole procedure until POSHE covers the whole input image.
5. After sub block histogram equalization finished, divide each pixel value in the output image array by its sub block histogram equalization frequency.

This method is more effective and much faster compared to other methods. But it needs an extra computation time for output scaling.

V. BRIGHTNESS PRESERVING HISTOGRAM EQUALIZATION

This method increases the enhancement while preserving the image detail. In this method curvelet transform function and histogram matching technique are used. The curvelet transform are used to fine the bright regions in the image. Firstly find out the bright region in the image, then histogram of the identified image are compared with the histogram of the original image. For this purpose wraparound discrete transform function are used. The curvelet transform is used for region identification and hard threshold is used for region separation. Let φ represent space domain curvelet then the curvelet transform of the image I is given by

$$\varphi = \varphi * I \tag{20}$$

Where * denotes the convolution operator. An image that contains mostly bright region I_B is given by

$$I_B = \varphi_{i,j}^{-1} (S_j(\varphi_{i,j})) - I \tag{21}$$

Where $\varphi_{i,j}$ represent i direction subband at j^{th} scale. S_j represent scale parameter for j^{th} scale subband. The identified image is identified by hard threshold parameter τ to separate the identified regions from other region of the original image. The parameter τ is image dependent and typically is varies from 0 to 1. The separated image

$$I_S = \tau(I_B) \tag{22}$$

The histogram of the image is identified by

$$P(X_K) = \frac{n_K}{N}, \text{ where } K = 0, 1, 2 \dots \dots, L - 1 \tag{23}$$

And its cdf is given by

$$C(r_K) = \sum_{j=0}^K P(r_i) \quad K = 0, 1, 2 \dots \dots, L - 1 \tag{24}$$

$$0 \leq C(r_K) \leq 1$$

Histogram matching or histogram specification is a non linear transformation method which changes shape of a given histogram to a desired one. Let us assume $P(X_K)$ is histogram of original image and $P_Z(Z)$ represent probability density function of desired image then

$$P_Z(Z) = \frac{n_K}{N} \tag{25}$$

A histogram matching between $P_r(r)$ and $P_Z(Z)$ are given by

$$S = T(r) = \int_{w=0}^r P_Z(w) dw \tag{26}$$

$$V = G(z) = \int_{w=0}^z P_Z(w) dw = s \tag{27}$$

Absolute mean brightness error and peak signal noise ratio is used to access the effectiveness of the proposed method. Formal access the degree of brightness while later preserving the degree of contrast enhancement. PSNR value of this method is better to other. This method is not always giving the best AMBE vale it preserves the brightness in the subjective sense.

VI. Image enhancement technique using weighted mixture of global and local transformation function

This method is based on the weighting mixture of local and global transformation function using mapping function. It increases both brightness and fine details of the input image. The final mapping function incorporates a local intensity pair distribution generated expansion function from each image block to control the enhancement of image details that the global transformation function along may fail to improve.

The basic idea of global transformation function is to divide input histogram into two parts based on the mean. These sub images are than further divided into sub images based on the mean and level of recursion r. The resulting 2^r histogram regions are equalized independently. Thus global transformation function is obtained as

$$T(g) = g_{min} + (g_{max} - g_{min}) \times \frac{\sum_{x=g_{min}}^g h(x)}{\sum_{x=g_{min}}^{g_{max}} h(x)} \tag{28}$$

Where g denotes the intensity value, g_{min} and g_{max} are lower and upper bound of histogram $T(g)$ is global transformation function. Local expansion function from intensity pairs distribution method exploits the neighbourhood information of all pixels to generate a global intensity mapping function. Different parts of image have different statistical characteristics, so block wise approach used to handle local information more effectively. Within each block generate the set of intensity pair $\{(a_1, b_1), (a_2, b_2), \dots \dots (a_j, b_j) \dots \dots (a_m, b_m)\}$ from a pixels 8-connected neighbours.

In a 2D image, many edge pairs exist near the edges. Therefore we accumulate all expansion forces between the edge pairs. The anti expansion force ensures the smoothness for homogenous regions in net expansion force. The net expansion force, F is obtained by

$$F_+(x) = F(x) + 1 \quad \forall_x \epsilon[a_j, b_j] \quad \text{if } |a_j - b_j| \geq \Delta I \tag{29}$$

$$F_-(x) = F(x) - 1 \quad \forall_x \epsilon[a_j, b_j] \quad \text{if } |a_j - b_j| < \Delta I \tag{30}$$

$$F = F_+ - W \times F_- \tag{31}$$

Where $F_+(x)$ is expansion forces and $F_-(x)$ is anti expansion force. Then the local expansions function from the intensity pair distribution.

$$G(g) = g + \sum_{x=g_{min}}^g F(x) \tag{32}$$

A weighted mixture of the expansion function and the global transformation function is computed by

$$M(g) = K \times G(g) + (1 - k) \times T(g) \tag{33}$$

Where K is the weight value $[0.0, 0.1]$.

This method give greater incremented in the image enhancement. But has one drawback. In the final mapping function $M(.)$ the local transformation function causes the output mean value can be shift and thus deviates from preserving the input mean brightness.

VII. ADAPTIVE IMAGE ENHANCEMENT TECHNIQUE BASED ON THE IMAGE CHARACTERISTIC

This method is based on the classification of the image characteristics. Firstly high pass filter (Laplace transform) is performed and after specification first order classifying of the image employed. The high pass filter is used to sharpen the edge of the image for low threshold value and low pass filter is used to smooth the image for high threshold image, Then second order classifying is used to adjust the brightness of the image based on the histogram of the first order classifying. It increased or decreased the brightness based on the result of first order classifying. At last step HE method of contrast enhancement applied to produce the output. It consists of four major function block such as sharpening pre-processing (SE), first order classifying intensity enhancement (FCIE), second order classifying and intensity enhancement (SCIE) and contrast enhancement.

Image sharpening pre-processing:-The second order partial differential equation along the 0, 45, 90,135 degree directions are expressed as

$$\frac{\partial^2 f}{\partial x^2} = f(x + 1, y) + f(x - 1, y) - 2f(x, y)$$

$$\begin{aligned} \frac{\partial^2 f}{\partial y^2} &= f(x, y + 1) + f(x, y - 1) - 2f(x, y) \\ \frac{\partial^2 f}{\partial x \partial y} &= f(x + 1, y + 1) + f(x - 1, y - 1) - 2f(x, y) \\ \frac{\partial^2 f}{\partial y \partial x} &= f(x + 1, y - 1) + f(x - 1, y + 1) - 2f(x, y) \end{aligned} \tag{34}$$

So the result of laplace filter is obtained by summing above four components:

$$\nabla^2 f = f(x + 1, y) + f(x - 1, y) + f(x, y + 1) + f(x, y - 1) + f(x + 1, y + 1) + f(x - 1, y - 1) + f(x + 1, y - 1) + f(x - 1, y + 1) - 8f(x, y) \tag{35}$$

All the values are scaled to the interval [0,255] by multiplying each pixel by the quantity 255/max, in the modified minimum modified values.

The first order classifying and intensity enhancement:-Let us assume MAXL and MINL are two positive threshold value. MAXL show the maximum threshold and is set to 32 and MINL represent minimum threshold is set to 16 based on experience.

If the low threshold image (AVEFL<MINL)

The output of the first order classifying and intensity enhancement is defined as

$$F_1(x, y) = f(x, y) + \alpha \cdot f^1 \tag{36}$$

α is positive factor and set to 0.25.

If the image belong to high threshold image (AVEF>MAXL)

Then the gauss filter belongs to low pass filter and its operator is weighted from the mast given below

$$G_m = \frac{1}{16} \begin{pmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{pmatrix} \tag{37}$$

The second order classifying and intensity enhancement:-To adjust the brightness of the image it used. If (AVEFI<MINI) then it is considered that the brightness of the image is so dark that improves by the rate of β . $F_i(x, y)$ The output of SCIE is defined as

$$F_i(x, y) = F_l(x, y) + \beta \cdot F_1(x, y) \tag{38}$$

B is a positive factor set to 0.125.

If (AVEFI>MINI) then the brightness of the image is considered so bright that reduces by the rate of β . Then

$$F_i(x, y) = F_l(x, y) - \beta \cdot F_1(x, y) \tag{39}$$

If AVEFI is between MAXI and MINI then the brightness of the image is neither too dark nor to bright.

$$F_i(x, y) = F_l(x, y) \tag{40}$$

Contrast enhancement:-HE is used for contrast enhancement.

$$P_b(b_i) = \frac{m_i}{m}, \text{ where } i = 0, 1, 2, \dots, L - 1 \tag{41}$$

And its cumulative density function is given by

$$C(b_k) = \sum_{i=0}^k P_b(b_i) \quad (42)$$

Thus the transform function of HE defined as

$$h(b_k) = b_0 + (b_{L-1} - b_0) C(b_k) \quad (43)$$

$$k = 0, 1, 2, \dots, L - 1$$

It is supposed that

$$G = G(x, y) \quad (44)$$

Is define as equalized output image, then

$$G = h(F) = \{h(F_i(x, y)) \mid \forall F_i(x, y) \in F\} \quad (45)$$

VIII. CONCLUSION

The comparative study of different method shows that content aware methods can improve images from a verity of different enhancement function based on the content of the image. Histogram equalization based method shows that the cases which require higher brightness preservation and now handled well by histogram equalization bi-histogram equalization, brightness preserving histogram equalization and sub block histogram equalization have properly enhanced. Image enhancements using weighted mixture of global and local transformation function give greater improvement in resultant image. Through these methods good contrast enhancement can be performed. The method based on image characteristic is adaptive image enhancement technique. It consists of major function block.

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