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Image Gap Interpolation for Color Images Using Discrete Cosine Transform

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Abstract— *Image Gap Restoration in color image is a developing field in image processing. The objective of my work is to restore the missing blocks in a digital color image. The method adopted here is a blend of interpolation and multiscale transformation. One of the best framework available to restore image gaps is multiscale transformation. It transforms an input image into a set of downscaled samples until the block size reduces to one. The popular methods used for image transformation are DCT (discrete cosine transform) and DWT (discrete wavelet transform). I am following DCT method in my project work. Two types of interpolation methods are used in my project work. In the first methods, the value of the missing pixel is obtained by taking the edge-weighted mean of the available neighboring pixel. The second method is an edge based interpolation. In this method, first, we find out the main edges of an image and its direction using any edge detection method like canny, sobel etc. the missing pixel value is calculated by using the available neighboring pixel along the same direction. The proposed algorithm gives improved PSNR (peak signal to noise ratio).*

Keywords— *Image gap, DCT, missing block, Restoration, Edge Detection, Interpolation.*

I. INTRODUCTION

Restoration of the gap in a digital color image is very important. The reason for image gap can be due to damage to the storage medium or transmission loss across the network. Image gap restoration has many applications including communication signal processing, econometrics, and numerical data analysis. It also helps to recover the damaged images from the older clips used in medical imaging, radar imaging etc.

In previous years, the three-methods used for restoring the image gap produced by the loss of blocks are (1) ARQ (automatic repeat request) (2) FEC (forward error correction code) (3) EC (Error concealment). In ARQ It consists of a transmitter and a receiver. The transmitter transmits the block one by one and ARQ uses an acknowledgement (send by the receiver it indicates that the receiver has received the error free block). If the transmitter does not receive an acknowledgement before timeout, Then the transmitter transmits the same block again until the transmitter receives an acknowledgement. ARQ has some disadvantage that it increases the channel bandwidth and it also produces some delay.so this is not used for real time application. In FEC the transmitter transmits some redundant bit with information to find the error and correction. FEC also has some draw back that it also produces delay and it increases the band width of the channel. So, this is also not suitable for real time application. The third method is the EC it is mainly based on the receiver. The main process included in EC are (1) Image transformation (2) Image interpolation. EC algorithm is used for real time application.

My work is based on the EC algorithm. Many interpolation algorithms are used for restoration of image gap. For example, linear, spline, bicubic etc. Most of these methods are suitable for interpolating stationary images i.e. (That is). This image contains no edges. For example, Low pass filter can be used for restoring the image gap of a stationary image contain no edges, no different pattern and no different objects. It gives a smooth replacement of the missing image gap. In real time scenario, an image can be nonstationary, having a mixture of pattern, objects, and textures. The main limitation of this interpolation algorithm are when they applied to an image consists of different pattern, different objects, different textures and edges then it produces a blurred appearance at the edges. My project is an approach to developing an advanced and more effective interpolation method to reconstruct the image gaps in a nonstationary image.

The purpose of image gap restoration is to recover the best matching of the original image degraded by gap, noise etc. The main objective of my work is to recover the still image (color image) degraded by gap, noise, etc. The proposed algorithm can also be useful for the restoration of video corrupted by gap, noise, etc. Standard image taken for the testing are Lena, pepper, man, boat, baboon (colour) and all are size of 512x512.The performance parameter of the proposed algorithm is the peak signal to noise ratio (PSNR) and structural similarity index (SSIM). The PSNR is the ratio of maximum signal power to the noise power. The SSIM is the measure of the similarity between the original image and restored image.

II. RELATED WORK

It provides the details of the related work for the restoration of gaps in a digital image. In [1], proposes an algorithm for the restoration of missing blocks using direction vector. The 8-edge direction vector is calculated using the edges of the neighbouring pixels and it is applied to interpolate the missing pixel. The eight-edge direction classification is performed using gradient filter. This algorithm improves the restoration of high-frequency content in a corrupted block.

In [2], introduces new technology for finding the missing block in jpeg and mpeg transmission. In jpeg, the image is divided in to 8 x 8 block and DCT is calculated for each block. Normally, low frequency coefficients contain valuable

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information and high frequency contain least information. So, we can easily neglect the high frequency coefficients. We have a group of pixels consisting of missing block and border pixels. The group of pixels are transformed using DCT and the high frequency DCT coefficient set to zero. The missing pixel value is estimated using the linear equation. But this algorithm is fails to recover the gaps near edges and the PSNR is also low.

In [3], presents an interpolation algorithm for the restoration of missing block in a still image. This algorithm uses edge information of surrounding pixel to restore the missing block. If the missing block is on the edge of an image, we need to estimate the edge orientation and direction using gradient filter. If the neighboring block contains no edges, then block restoration is done by the smoothening process.

In [4], introduces an algorithm for restoration of missing block size M, 8M vectors are calculated from neighbourhood of M x M missing blocks. From these vectors, find the closest spatial information for missing block. For restoring the missing pixel, two recovery vectors are used. First one is a correctly received pixel and the second one is an estimated missing pixel. The recovery direction is chosen in accordance with the orientation of edges.

In [5], introduces an algorithm for restoration of missing block in frequency domain. The missing pixel value is obtained by taking the DCT average of 4 connected neighbouring block. If the neighbourhood contains an edge this algorithm gives poor result. To improve the result, consider 8 neighbourhoods instead of 4 neighbourhoods.

In [6], introduces an algorithm for restoration of missing block in a jpeg image transmission. There are two methods are used for restoration, first one is estimating the value of dc coefficient from available 4 connected blocks. If the missing block has no neighbourhood the dc estimate of missing block set to zero. It will create some artifacts in the image. To remove this artifact some methods are used in this paper. The second method is the all other coefficients are extracted from the 4 connected blocks.

The aim of my work is to restore the image with high PSNR as compared to the other published work. The paper is organized is as follows. The proposed method is explained in section III, the results are demonstrated in section IV and the conclusion are explained in section V.

III. THE PROPOSED IMAGEGAP INTERPOLATION

A. *Two Dimensional DCT Image Transformation*

In the proposed method first take a test color image of size 512*512.Test image taken are Lena, man, pepper, baboon etc. If the image size is not 512*512, then the input image is converted in to 512*512 using 'imresize' MATLAB command. Before processing the color image, the input image is divided in to red, green and blue plane using the equation (1), (2) and (3).

$$R = I(:, :, 1) \tag{1}$$
$$G = I(:,:, 2) \tag{2}$$
$$B = I(:,:, 3) \tag{3}$$

Where I is the input image and R, G, B is the corresponding red, green, and blue images. Which is shown in Fig. 1. Each image plane is processed one after another that means first process the red plane, then process the green plane and at the last blue plane and after processing of all plane these results are combined to produce the output image.

First take the red plane image and is divided in to 8 x 8 block and make corruption on the image. The corruption may be regular or random. The regular corruption on the image means the block loss must occur at regular basis. The random corruption means the block loss occur at random fashion. The corruption means the selected 8x8 block set to zero. Similarly make corruption on the green and blue plane and after corruption these three images are combined using concatenation function to produce the corrupted color images. This is shown in Fig. 2.


Fig. 1. (a) Original image (b) Red image (c) Green image (d) Blue image.


Fig. 2. (a) Original image (b) Regular corruption (c) Random corruption.

The input image size is 512x512 and the block size is either 8x8 or 16x16 block. Due to this large block size, the calculation becomes more complicated and it takes more time to complete the operation to make calculation simpler the original image is transformed in to different scale using any transformation method. Commonly used transformation methods are FFT (fast Fourier transform), DCT (discrete cosine transform), DWT (discrete wavelet transform). I used DCT here for image transformation, because DCT Easy to use, more compatible. Two Dimensional DCT is used for image transformation. Here DCT is used as a pyramid, the number of layer of pyramid depends up on the block size. If the block size is 8x8 block, then three layers of pyramid is used to convert 8x8 block to 1x1 block or if the block size is 16 x16 then four layers of pyramid is used.

At the base of the pyramid the image is 512x512 and the block size is 8x8. First two dimensional DCT is applied on red plane image, The DCT transformed image contains low frequency coefficient on the left top position and high frequency coefficients on the right top position. Normally the low frequency co efficient contain most information and high frequency contains least information. In each block retains the low frequency and discard the high frequency co efficient. Then each block is reducing to 4*4 block and image is down

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scaled in to 256*256.Take IDCT (inverse discrete cosine transforms) of DCT transformed image to produce the image in time domain. This image is the input for the next layer of pyramid. The same process repeat until each block reduces to 1. At the last stage of downscaling the image size reduce to 64*64. After red plane image decomposition using DCT the same process is applied to the green plane and then blue plane. After all plane decomposition, the all results are combined to produce the single-color image. The DCT transformed image is shown in Fig. 3.

The 2D DCT equation of an Ms x Ns of matrix I at the first layer of the pyramid is as follows

$$B_{xy1} = b_x b_y \sum_{m=0}^{Ms-1} \sum_{n=0}^{Ns-1} I(m,n) \cos\frac{\pi(2m-1)x}{2Ms} \cos\frac{\pi(2n-1)y}{2Ns} \quad (4)$$

Where the subscript 's' indicate the level of DCT transformation. For example, at the first level s=1, then M1=N1=8x8, at the second level M2=N2=4x4, at the third

Fig. 3. Four level 2D IDCT (512x512, 256x256, 128x128, 64x64).

level M3=N3=2x2 and at the last stage M4=N4=1x1.

The value of x ranges from o to Ms-1 and the value of y ranges from 0 to Ns-1.

$$x = 0 \leq Ms - 1 \quad (5)$$

$$y = 0 \leq Ns - 1 \quad (6)$$

i.e. at the first level the value of x and y ranges from 0 to 7, at the second level it ranges from 0 to 3, at the third level it ranges from 0 to 1 and at the last stage the value of x and y is zero.

I (m, n) is the input image matrix where m is the number of rows and n is the number of columns, bx and by are the DCT constant of coefficient and the value is given as follows

$$bx = \begin{cases} 1/\sqrt{Ms} & x = 0 \\ \sqrt{2/Ms} & x \neq 0 \end{cases} \quad (7)$$

$$by = \begin{cases} 1/\sqrt{Ns} & y = 0 \\ \sqrt{2/Ns} & y \neq 0 \end{cases} \quad (8)$$

B. Image Gap Interpolation

After the successful image transformation, the image is reducing from 512x512 to 64x64 and the interpolation start at the final stage. Before doing the interpolation, we must find the missing block. The missing block is found by using 'find' function in MATLAB. The find function returns the coordinate of the pixel with zero intensity. Interpolation means finding the missing pixel intensity using the correctly received pixel. The interpolation starts at the last stage of transformation. Two types of interpolation methods are used in my project work. In the first methods, the value of the missing pixel is obtained by taking the edge-weighted mean of the available neighboring pixel. In the second method first find the edges of an image using any edge detection method i.e. canny, sobel, and prewitt and then find the direction. The value of missing pixel value is calculated by using the available neighboring pixel along the same direction.

(1) Interpolation of gap based on local edge information

To do interpolation of missing gap using local edge information first find out the local edge. The local edge means whose intensity are varying slowly. The interpolation starts at the final stage of transformation where the missing gap is reducing to one. To find the local edge we need to find the missing pixel. After finding the missing pixel we must find the eight-neighbor pixel around every pixel. In the Fig. 4 the black region represents the missing pixel, the red region above and below the missing pixel indicates the horizontal edge, the green region left and right of the missing pixel indicates the vertical edges the blue region represents the left cross neighbor of the missing pixel and the yellow region represents the right cross neighbor of the missing pixel.

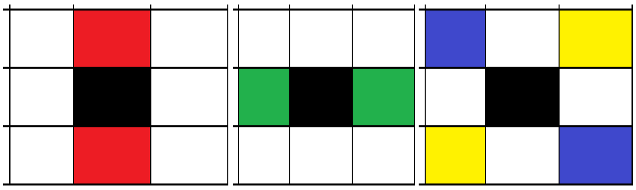

Fig. 4. (a). Horizontal (b) Vertical (c) Left and right cross edges.

For finding the direction of local edge we must calculate the difference between the pixel around the missing gap. For example, the difference between red region, difference between green, difference between blue and difference between yellow. Among these four differences find the minimum distance which belongs to the direction of interpolation. The value of missing pixel value is the mean of the pixel those which are in the same direction.

After interpolation using local edge information get an interpolated image with perfect interpolation at smooth area and some blurred distortion at the main edges. For further enhancement need to do another interpolation using global edge information.

(2) Interpolation of gap based on global edge information

Global edge is the main edge of the image i.e. the boundary between the two objects. To get the edge use any edge detection method like canny, sobel etc. Nowadays the popular edge detection method is canny. Because it provides better edge detection compared to the other method. Canny edge detection method is the multistage algorithm. It consists of five level of operation. The first level is the application of Gaussian filter to remove the noise of an image. The second level is the finding of gradient of an image. Each edge in an image points in eight directions i.e. horizontal, vertical and diagonal. The canny algorithm uses some filters to find the eight directions.

Gradient of an edge is the directional change in intensity. It is expressed in equation (9).

$$M = \sqrt{M_x^2 + M_y^2} \quad (9)$$

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Where M is the gradient, Mx is the first derivative in x direction and My is the first derivative in y direction. The direction of angle is represented in equation (10)

$$\theta = atan2\,(Mx,\, My) \tag{10}$$

The angle is rounded to one of four angles (0, 45, 90, 135). The third level of canny is the non-maximum suppression. It is used to thin the Edge. The fourth level is the application of threshold to eliminate the unwanted edge. The final stage is the edge tracking by hysterics The five-level canny algorithm is shown in Fig. 5 and the four-layer canny image is shown in Fig. 6.

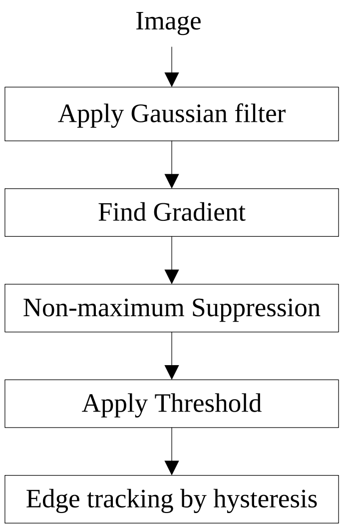

Fig. 5. Canny edge detection algorithm.

Fig. 6. Four level canny image (512x512, 256x256, 128x128, 64x64).

After the edge detection check whether the missing gap is present in the detected edge or not. If the missing gap present in the edge find the gradient magnitude and direction using the equation (9) and (10). The value of missing pixel is the mean of the pixel those which are in the same direction. Then get a perfect image at the edges and the other regions also.

C. DCT Based Up sampling

Up sampling is the process of increasing the image size. Different types of up sampling methods are available today. For example, linear methods, weighted average methods etc. Here We adopted a DCT based up sampling methods. The edge enhanced image is of size 64 x 64, the conversion of the image size from 64 x 64 to 128 x 128 use DCT based up sampling methods. If you want to up sample an image size (m x m) to (n x n) using DCT method, first calculate the DCT of input image of size (mx m), then we get a DCT transformed matrix of size (m x m). Next padd (n-m) zeros to the row and (n-m) zeros to the column of DCT transformed matrix. Then take IDCT of the zero-padded matrix we get an up sampled image of size n x n.

D. Merging of Two Images

After up sampling the image, it is added with the same size image in the IDCT image. After merging the same process (interpolation, up sampling, merging…) repeats until the image size becomes 512 x 512.

IV. Simulation Results

To performance evaluation, the proposed algorithm is tested on many test images like Lena, pepper, man, baboon (color image) of size 512x512. The missing block size is set to 8x8. Two types of missing blocks are evaluated; Regular missing block of Lena color image is shown in Fig. 7 and Pepper image is shown in Fig. 8. Random missing block of Lena image is shown in Fig. 9 and Pepper image is shown in Fig. 10. The only performance parameter is the PSNR. The PSNR is the ratio of maximum signal power to the noise power.

$$PSNR = 20\,\log \frac{max}{rmse}\,db. \tag{11}$$

Where max is the 255 and rmse is, the root means square error. The PSNR of color image is the mean of PSNR of red, green, and blue images.

Fig. 7. Lena image with regular missing block.

Fig. 8. pepper image with regular missing block.

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Fig. 9. Lena image with random missing block.

Fig. 10. pepper image with random missing block.

V. CONCLUSION

I have proposed a method for restoration of missing block in a still color image. The proposed method is a blend of interpolation and multiscale transformation. This algorithm can capable of restoration of missing block including edges. In my work DCT is used as the multiscale transform. The edge based interpolation is used here for restoring the gap in the edges. The method was tested on many standard test images such as Lena, man baboon, pepper etc. All image is of size 512*512. Both grey image and color image are tested with different loss rate for regular and random block loss. Competitive result in the picture quality and PSNR as compared to other method is obtained. This algorithm can also capable of restoration of video, which is distorted by gap or noise.

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