ROI Based Near Lossless Hybrid Image Compression Technique

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Abstract— **Region of Interest based compression is an efficient method of compression for images with a particular part to be most significant. It is always a better choice to compress the ROI with lossless compression while the rest of image with lossy compression technique. This paper deals with the compression of color images with the face of the person (ID cards, voter ID). This paper proposes lossless compression for face (ROI) and near lossless compression for the rest of the image. Image other than ROI may contain information that is useful, that is why it is appropriate to use near lossless compression for the rest of the image. Face detection suggested in this paper detects the face with the detection of skin color and natural dimensional ratio of height to width of normal human face. In this method of compression, PSNR obtained is remarkable and compression ratio can be increased by increasing the base value which is in power of two. In this method of compression, face will be compressed completely lossless by using Huffman coding and Snake difference scanning is used for achieving a good compression ratio. Proposed algorithm provides quality PSNR with reasonable CR with lossless compression of ROI.**

Keywords—ROI (Region of interest); Near lossless compression; PSNR (peak signal to noise ratio); CR (Compression ratio); Snake scanning; Huffman coding; Face detection.

I. INTRODUCTION

In this era of digital science, the transmission of information takes place worldwide by means of communication channels. This information has to be transmitted faster and in a very compact size. Reducing the size of data content sent, increases the rate of transmission and saves the energy required for transmission. In particular, when the image is sent, it becomes necessary to compress it, while doing this quality of the recovered image should not be compromised. There are two compression techniques for image compression, lossy and lossless image compression. Lossy compression techniques achieve a high compression ratio, but it compromises the quality of recovered image (low PSNR). Lossless compression achieves high quality of recovered image (high PSNR) but unable to achieve a good compression ratio. Method of compression, which can achieve good CR without risking the quality of recovered image (high PSNR) can be the best substitute for these two compression techniques. Hence this paper deals with Near lossless compression technique. In any image only part of an image is significant like in ID cards (Identity cards), voter ID and photographs, face of a person is significant, call it ROI [1] in the context of this paper. In general various compression techniques, [2] compress the whole image by either lossy or lossless compression. Performance of compression can be increased by using lossless compression for ROI [3] and lossy compression [4] for the rest of the image. In this technique ROI (face) is compressed with lossless compression while the rest of the image by near lossless compression. The reason, Near lossless compression [5] preferred for the rest of the image is, despite of insignificance of region of image other than ROI, it may contain information which is significant such as name, address or roll number etc.

II. NEAR LOSSLESS IMAGE COMPRESSION

Compression algorithm proposed is appears to be lossless by name, but it is lossy. As compared to other lossy compression techniques it resembles the characteristics of lossless technique. The percentage of loss by proposed algorithm is less as compared to other lossy compression techniques. In near-lossless compression [6] pixel intensity values are guaranteed to be within a specified range based on the near-lossless threshold. In reconstructed image value of pixel intensity differs from original pixel value not more than predetermined value. Many images generally show Statistical redundancy, which occurs due to fact that pixel intensity values of neighboring pixels are similar. The near lossless compression method works on removing this statistical redundancy by dividing image pixels by certain base value and taking integer parts of the quotient, followed by snake difference scanning followed by Huffman coding.

III. ROI SELECTION BY FACE DETECTION

The method used for face detection [7] [8] is skin color filtering, but it has some limitations. These limitations can be compensated by using other filtering methods simultaneously with skin color filtering [9]**.** While detecting face by skin color, face is not only object that could be found in an image, also necks, arms, legs, and palms will found by the skin color filtration method. In order to avoid this, criteria of height to width ratio [10] of the standard human face can be applied to sort out face region from skin color detected regions [9].

A. Algorithm to detect face

Step 1. Input the image.

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Step 2. Find out the normalized RGB image (rgb(i, j)) and HSV image (HSV(i, j)) from the input image.

Step 3. For each pixel (i, j), get the corresponding normalized r and g value, also H and S values.

Step 4. Fix the threshold for r, g, H, S to get the mask for separating the skin region from the image.

Mask 1-

$$0 < H(i, j) < 0.5934 \text{ or } 6.0563 < H(i, j) < 6.2657 \quad (1)$$

Mask 2-

$$0.2 < S(i, j) < 0.757 \quad (2)$$

Mask 3-

$$0.4 < r(i, j) < 0.6 \text{ and } g(i, j) > \frac{1 - r(i, j)}{2} \text{ and } g(i, j) < r(i, j) \quad (3)$$

Step 5. Multiply these three masks to get the final mask.

Step 6. Perform Binary Mask Post-Processing

This can be achieved by performing morphological operations on the mask image, which removes holes and unnecessary regions in the mask and also eliminates some small masked regions. The operations to be carried out on the image are erosion followed by the dilation.

Step 7. Image Segmentation on the basis of Shape Based Filtering

This processed mask image is segmented using a connected component labeling. Segmentation to be carried out has to pass the test of shape based feature which is an aspect ratio of width to height of the region.

Conditions that to be passed, for the region to be recognized as face region are as follows:

Condition1:

$$(10/7) \times \text{RegionHeight} > \text{RegionWidth} > (3/10) \times \text{RegionHeight} \quad (4)$$

Condition 2:

$$(1.6) \times \text{RegionWidth} > \text{RegionHeight} > (1.19) \times \text{RegionWidth} \quad (5)$$

Step 8. Segment the face from an image by using obtained mask.

IV. Reducing the Range by Base Value

Range of pixel intensity values can be reduced and made continuous range, by dividing the pixel values by the base value [11], where base is any value between 2 to 32. For image excluding ROI, simple arithmetic operation is performed on pixel values, only the integer part is retained and the remainder is truncated. This operation increases CR, and only little amount of information of the image is lost. To maintain high quality, the base should be small and high compression can be achieved by increasing the base value.

V. Scanning

Neighboring pixels show similar pixel values, the main objective of scanning is such that same pixel value neighbors should be arranged in the immediate vicinity. There are many scanning methods like Raster scanning, Zigzag Scanning, Orthogonal scanning and Snake scanning. Out of these Scanning, Snake scan appears to provide the best results.

In Snake scanning, matrix of the image is scanned in such way that all the three neighbors of a pixel in 2 by 2 block will be arranged in single row one after another. This technique is helpful in achieving good CR because of psycho visual effect. Human eyes are not able to differentiate between small change in intensity between a short span of distance, if such pixel arrangement exists then it is called as psycho visual redundancy. Snake scanning assemble all such pixels in a row and on this row DPCM is applied, which removes the psycho visual redundancy.

Snake scanning procedure explained above is shown in the diagram below.

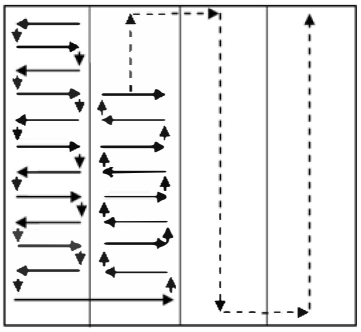


Fig. 1. Snake Scanning

VI. Difference Block

Pixel values obtained from scanning are used as input to the difference block which takes difference of current pixel with previous pixel to get the new value. After this block range of pixel values obtained will be very small, these values are further encoded by Huffman coding to get desired compression.

VII. Huffman Encoding

Huffman code [12] is a variable-length code. The variable length code assigns codes which are of variable length to

symbols to be encoded. Variable length codes provide a way to encode the symbols in a lossless way of compression. Huffman codes are widely used lossless image compression technique.

The Huffman code procedure is based on the two implications.

1) Symbols with higher frequency will have shorter code words than symbol that occur less frequently.
2) The two symbols those occur least frequently will have the same length.

VIII. ALGORITHM USED

A. Compression

Step 1. Input the image having human face.

Step 2. Send the image for face recognition and get the coordinates of face detected region.

Step 3. Divide the each pixel of the whole image by base value.

Step 4. Segment the image in ROI and a non ROI image from the coordinates obtained from step2.

Step 5. Round-off the non ROI region pixels to integer value and keeping ROI region pixels as it is.

Step 6. Apply Snake scanning; arrange the pixels in 1 D matrix of specific scan order.

Step 7. Apply difference coding. Suppose W(i) is the pixel obtained after snake scanning, then

$$Wd(1) = W(1) \tag{6}$$

$$Wd(i) = W(i) - W(i-1) \tag{7}$$

Where, i = 2, 3, 4..., n.
(n is the total number of pixels in the image)

Step 8. Apply Huffman encoding to obtain a sequence of variable length codes.

B. Decompression

Step 1. Apply Huffman decoding procedure to obtain the symbols (pixel values) provided as input to Huffman encoding.

Step 2. Apply Inverse difference coding. Suppose Wd(i) is the pixel obtained after Huffman decoding, then

$$Ws(1) = Wd(1) \tag{8}$$

$$Ws(i) = Wd(i) + Ws(i-1) \tag{9}$$

Where, i = 2, 3, 4..., n.
(n is the total number of pixels in the image)

Step 3. Apply Inverse Snake scanning on Ws(i) to arrange the pixels in 2 D matrix as the original image.

Step 4. Multiply each pixel by same base value, which was previously used for division.

Step 5. Output is reconstructed image similar to the original input image.

IX. EXPERIMENTAL RESULTS

Algorithm explained here is operated on many images having human face. Images have been operated are Adhar card, Identification cards, election commission Id cards and other images with a human face in it. In this paper, the performance of discussed compression technique is tested on basis of CR and PSNR. These criteria are tested on whole images. ROI is compressed totally lossless, while the rest of the image compressed in a lossy manner. Hence PSNR is calculated for total image rather than for different region. Experimental results show that, as the base value increases, PSNR decreases with increase in CR, while maintaining highest quality of ROI [1] (here in this context face of the person).

Peak Signal to noise ratio (PSNR) is calculated by following formulae,

$$MSE = \sum_{i=1}^{m} \sum_{j=1}^{n} \frac{[X(i,j) - Y(i,j)]^2}{m \times n} \tag{10}$$

$$PSNR = 20 \times \log[255/\sqrt{MSE}] \tag{11}$$

Where,

X(i, j) = Original image;

Y(i, j) = Recovered image after decompression;

m and n are height and width of the image;

MSE = Mean Square Error;

Compression ratio (CR) is calculated by following formulae,

$$\text{Compression ratio} = \frac{\text{Original image size}}{\text{Compressed image size}} \tag{12}$$

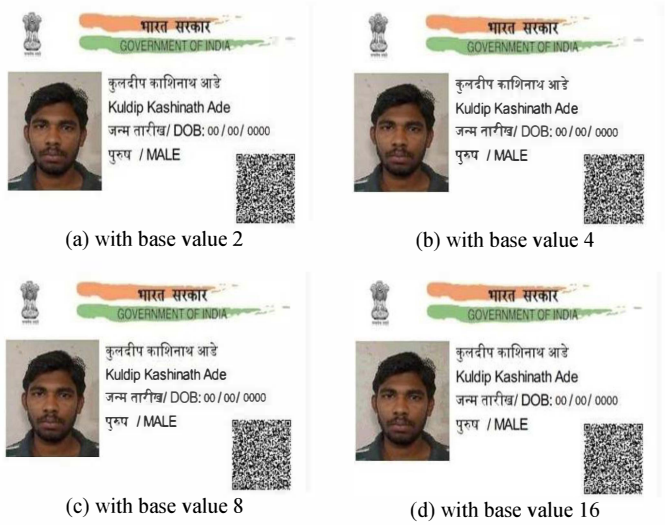
Values of CR and PSNR are calculated at different base values which are 2, 4, 8, 16, and 32. PSNR obtained by this method of compression is remarkable with good compression ratio. Results are best with a base value of 8, this base value provides a satisfactory combination of PSNR and CR. The average of the compression ratio and Average of PSNR for images operated under this algorithm is found to be 2.89765 and 41.7048 respectively.

Table I. PSNR and CR for different base values

IMAGES	Base value	2	4	8	16	32
Adhar card	***PSNR***	54.6188	49.9967	44.4511	38.9574	33.6400
	CR	2.3090	2.6843	3.1249	3.6512	4.1973
president	***PSNR***	51.8661	47.0423	41.5263	35.6809	29.6254
	CR	1.9729	2.2503	2.5945	2.9835	3.3852
Election ID	***PSNR***	51.4528	46.6905	41.0354	35.1166	29.0758
	CR	1.4565	1.7357	2.0973	2.7013	3.4030
Canada PM	***PSNR***	51.5044	46.7023	41.1923	34.4931	29.4282
	CR	2.3316	2.8672	3.4814	4.0711	4.6548

X. CONCLUSION

The algorithm proposed in this paper, Hybrid near lossless image compression. Proposed algorithm provides the best way to compress the image on the basis of priority of regions. ROI is compressed with lossless compression technique at the same time good compression ratio is achieved. Simplest arithmetic operations are used for compression, which not only reduces hardware complexity, but also increases the speed required for compression. The proposed algorithm provides good picture quality even at high compression. ROI is kept lossless; hence PSNR for ROI is very high. This algorithm can be used in many applications depending on the criteria of selection of ROI [13] [14]. Medical images found to be suitable for this algorithm, if ROI selection is based on unwanted or forensic materials in the human body.



(a) with base value 2 (b) with base value 4

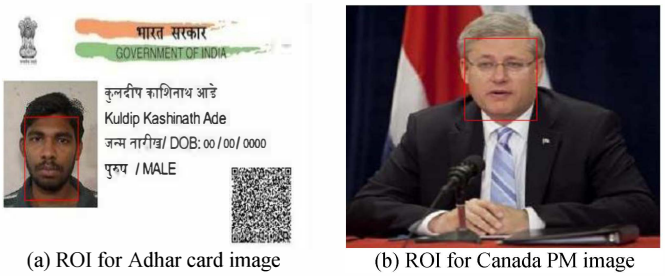
(c) with base value 8 (d) with base value 16

Fig. 2. Reconstructed images of Adhar card for different base values.

(a) with base value 2 (b) with base value 4

(c) with base value 8 (d) with base value 16

Fig. 3. Reconstructed images of Canada PM for different base values



(a) ROI for Adhar card image (b) ROI for Canada PM image

Fig. 4. Region inside the red box is the ROI and the rest of the image is non ROI.

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