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Image Enhancement Using Filter To Adjust Dynamic Range of Pixels

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ABSTRACT:
In this paper, we propose a novel algorithm for image enhancement in compressed (DCT) domain. Despite, few algorithms have been reported to enhance images in DCT domain proposed algorithm differs from previous algorithms in such a way that it enhances both dark and bright regions of an image equally well. In addition, it outperforms in enhancing the chromatic components as well as luminance components. Since the algorithm works in DCT domain, computational complexity is reduced reasonably.

I. INTRODUCTION

To improve visualization in the field of image processing the technique of enhancement is used. Research in human Psycho-visual system yields an idea to compress an image by removing redundant information without affecting its quality. One such widely used compression standard is JPEG [2] (Joint Photographic Experts Group). Basic building block of JPEG compression is Discrete Cosine Transform [2] which transforms an image from spatial domain to compressed domain. 2D DCT with quantization, zigzag alignment, and run length coding are used to encode the data in JPEG.

Today various techniques exist to compress image both in spatial and DCT domain. Spatial domain enhancing technique originates from histogram equalization and spans widely to low pass filtering, un-sharp masking, and high pass filtering, etc. These enhancing techniques achieve desirable result in enhancing gray-level images. But in modern days, we are inspired with less storage space for data storage and speed up in data transferring. Since all the previous mentioned algorithms work in spatial domain [10], they fail to provide compression. However these algorithms could be used in pre-compression and post compression stages as reported in [7] with increased complexities and reduced computing speed. Other drawback with these algorithms is they work only with gray-level images.

Modifications to these algorithms have been reported to work with color images as well, but still in spatial domain. Technique has been reported to enhance the contrast alone of the image by considering the DCT coefficients as the different band sets [7]. This is one of radical technique which brought the attention of researchers to develop enhancing algorithms in DCT space. However this algorithm speaks enhancement of contrast alone. Alpha rooting [3, 9, and 11] and multi contrast enhancement [7] are other algorithms to work in DCT domain. These algorithms did not report with processing on chromatic components. Further they use non-uniform scaling constants for various bands of frequencies of DCT block. With this motivation and background, we present an algorithm in such a way

1) To enhance both dark and bright regions of an image equally well.
2) To enhance chromatic components as like as luminance component.
3) To enhance with uniform scaling coefficient for all frequency band sets of DCT blocks.
4) To enhance with complexity reduction because it works in compressed domain.

II. DISCRETE COSINE TRANSFORM

For a 2D image say, I(x, y) DCT coefficients are obtained as,

$$W(p,q) = \frac{2}{N}\alpha(p)\alpha(q)\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} I(x,y).cos\left(\frac{(2x+1)\pi p}{2N}\right).cos\left(\frac{(2y+1)\pi q}{2N}\right) \quad (1)$$

Where

$$\alpha(p) = \alpha(q) = \begin{cases} \frac{1}{\sqrt{2}} \; for \; p = q = 0 \\ 0, \quad otherwise \end{cases} \quad (2)$$

Since DCT is a linear transformation, scaling and superposition applied in DCT domain will be reflected in spatial domain as well and vice versa. Block DCT space is used in JPEG with a block size as 8 X 8 [2]. JPEG takes advantage of human visual system which is less sensitive to high frequency components than low frequency components, hence quantize, and loose unwanted high frequency coefficients. Mean while, JPEG prefers Y-Cb-Cr space to compress the image, since chromatic components are less correlated in Y-Cb-Cr color space than R-G-B Space, [2]. As per human visual system, Contrast is defined as the ratio of high frequency terms to low frequency terms. This means, contrast is the ratio of standard deviation over a block to mean of the block [Weber law]. Weber law defines the contrast in DCT space as

$$C = \frac{\delta}{\mu} \qquad (3)$$

Where μ is the mean and δ is the standard deviation of DCT block respectively. In a block, mean is defined to be the DC coefficient as

$$\mu = \hat{w}(0,0) \qquad (4)$$

And standard deviation is defined as

$$\delta = \sqrt{\sum_{x=0}^{N-1}\sum_{x=0}^{N-1} \hat{w}(x,y)^2 - \mu^2} \qquad (5)$$

Where $\hat{w}$ is the normalized constant defined to be

$$\hat{w}(p,q) = \frac{W(p,q)}{N} \qquad (6)$$

From (4), and (5), it is verified that contrast is the ratio of high frequency coefficients to low frequency coefficients.

For Y-C_b-C_r Color Space the luminance component, C_b and C_r the chrominance components are represented as the linear combination of R, G, and B respectively. Relation is described as

$$\begin{pmatrix} Y \\ C_b \\ C_r \end{pmatrix} = \begin{pmatrix} 0.256 & 0.502 & 0.098 \\ -0.148 & -0.290 & 0.438 \\ 0.438 & -0.366 & -0.071 \end{pmatrix} \begin{pmatrix} R \\ G \\ B \end{pmatrix} + \begin{pmatrix} 0 \\ 128 \\ 128 \end{pmatrix} \qquad (7)$$

III. PROPOSED ALGORITHM

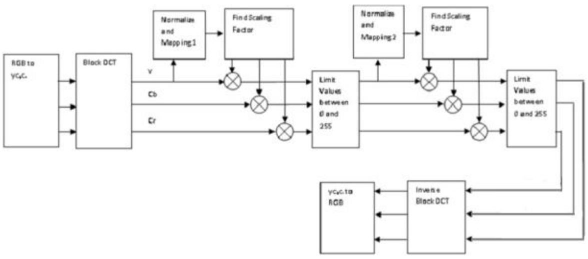

Fig 1. Block diagram for color image enhancement in compressed DCT domain

Presented algorithm does the enhancement in two passes as shown in fig 1 and the idea here is to adjust the dynamic range of the pixels. A function which rises exponentially is used to adjust the dynamic range during the first pass. This function is described in (8). This function serves better in enhancing darker region of an image. A function which decays exponentially is used to adjust the dynamic range during the second pass. This function is shown in (9). This function enhances the bright region of an image well.

$$f = \frac{e^x}{2.7183} \qquad (8)$$

And

$$f = e^{-x} \qquad (9)$$

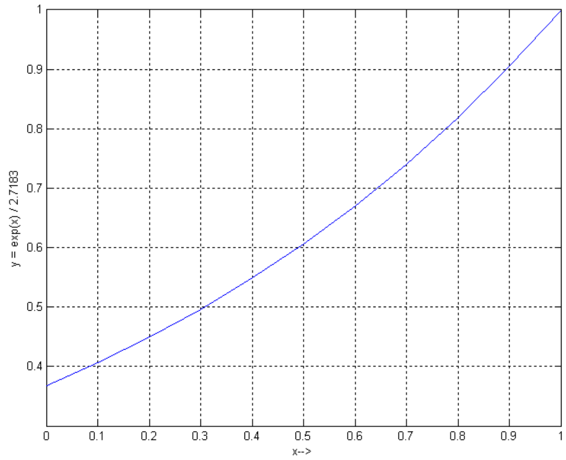

Fig 2. Plot of function in (8)

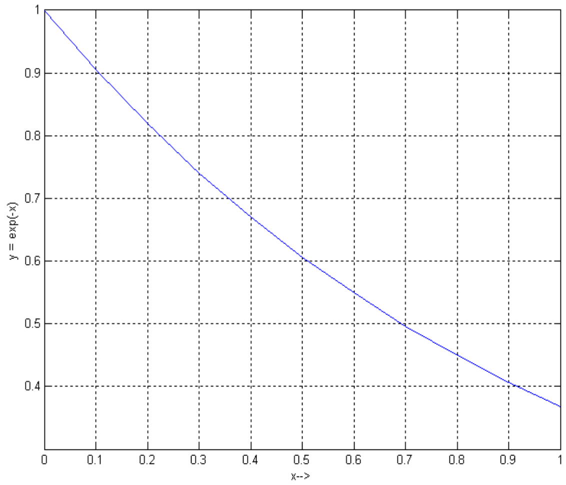

Fig 3. Plot of function in (9)

Plots of these two functions are shown in the fig.2 and fig.3. The algorithm aims at finding the factor λ which is mentioned in [7] using both the functions. DC coefficient of a block is normalized and translated slightly higher in amplitude with the help of function shown in (8). This translated value is divided by actual value to find the factor λ as shown in (10).

$$\lambda_1 = \frac{e^{\frac{w(0,0)}{N.l_{mx}}}/2.7138}{\left({}^{w(0,0)}/_{N.l_{mx}}\right)} \qquad (10)$$

Where , l_{mx} is the maximum pixel value of all blocks. Now, all the coefficients of luminance block are multiplied by this λ to enhance spatial domain pixel values. Since Multiplication is done with all DC and AC coefficients by the same factor, over all contrast of the block is kept unvaried. This could be written in equation as

$$\bar{Y}(p,q) = \lambda.Y(p,q), \quad for\ all\ p\ and\ q \qquad (11)$$

Similar procedure is used for chromatic components as well. In processing the chromatic components, we enhance the color details of an image.

$$\overline{C_b} = \begin{cases} N.\left(\lambda.\left(\frac{C_{b(p,q)}}{N} - 128\right) + 128\right), p = q = 0 \\ \lambda.C_b(p,q), for\ other\ p\ and\ q \end{cases} \qquad (12)$$

$$\overline{C_r} = \begin{cases} N.\left(\lambda.\left(\frac{C_{r(p,q)}}{N} - 128\right) + 128\right), p = q = 0 \\ \lambda.C_r(p,q), for\ other\ p\ and\ q \end{cases} \qquad (13)$$

IV. RESULTS

We have taken a test image shown in fig. 4 and fig 7. Result obtained after first pass is shown in fig 5 and fig 8.Result reveals that darker regions are well enhanced but with too much brightness. This excessive brightness need to be removed during the second pass. Output image from first pass is given as input to the second pass. Procedure is same as above, except it uses different λ for range adjustment as already explained. This explanation is supported with (14). Treatment to chromatic components is also similar. Equations (11), (12) and (13) support this theoretical discussion.

$$\lambda_2 = \frac{\lambda_1}{3} \qquad (14)$$

Results obtained after second pass is shown in fig.6 and fig 9. One could see from this figure that too much brightness visible during the first pass is removed. In addition; enhancement over bright and dark regions is performed.

Fig 4.Original Tower Image

Fig 5.Output of Filter one

Fig 6.Enhanced Image

Fig 7.Original Leena Image

Fig 8.Output of Filter one

Fig 9 .Enhanced Image

V. CONCLUSION

In this paper an algorithm is presented to enhance images in the compressed domain. Proposed Algorithm is less complex and it outperforms in enhancing chromatic and luminance components equally well. The values from JPQM and PSNR metrics insist that quality after enhancement is improved. Algorithm is faster than the efficient image enhancement in compressed domain

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REFERENCES

[1] Gregory K. Wallace, “The JPEG still picture compression standard,” in IEEE transactions on consumer electronics, vol ,pp. dec 1991.
[2] S. Aghagolzadeh and O. K. Ersoy, “Transform image enhancement,”Opt. Eng., vol. 31, pp. 614–626, Mar. 1992.
[3] T.Tadashi Kasezawa, “Blocking artifacts reduction using discrete cosine transform,” IEEETrans.Consumer Electron., vol. 43, no. 1, Feb.1997.
[4] S. S. O.Steven S. O. Choy, Y.-H.Yuk-Hee Chan, andW.-C.Wan-Chi Siu, “Reduction of blocktransform image coding artifacts by using local statistics of transform coefficients,” IEEE Signal Processing Letters, vol. 4, no. 1, pp. 5–7, Jan.1997.
[5] Z. Wang, H. R. Sheikh, and A. C. Bovik, “Noreference perceptual quality assessment of JPEG compressed images,” in Proc. Int. Conf. Image Processing, Rochester, NY, Sep. 2002, vol. I, pp. 477–480.
[6] J. Tang, E. Peli, and S. Acton, “Image enhancement using a contrast measure in the compressed domain,” IEEE Signal Process. Lett., vol. 10, no. 10, pp. 289–292, Oct. 2003.
[7] Ying Luo and Rabab K. Ward , “Removing the Blocking Artifacts of Block-Based DCT Compressed Images”, IEEE transactions on Image Processing, Vol. 12, No. 7, July 2003.
[8] Yasuyuki Shibuya, etal,”Alpha E- and Alpha Ncatenin Expression in Dorsal Root Ganglia and Spinal Cord”, Kobe J. Med. Sci., Vol. 49, No. 4, pp. 93-98, 2003.
[9] Chi-Farn Chen, Hung-Yu Chang, Li-Yu Chang, “A Fuzzy-based method for remote sensing image contrast enhancement,” The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol. XXXVII. Part B2. Beijing 2008.pp995-999.