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AN IMPROVED CONTRAST ENHANCEMENT APPROACH FOR PANORAMIC DENTAL X-RAY IMAGES

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ABSTRACT

The Panoramic Dental X-ray image is an important tool for a thorough dental examination. These X-ray images suffer from poor contrast because of the luminance non-linearity introduced by medical imaging techniques. Hence an automatic method of image enhancement of panoramic X-ray image is essential. A novel method of improving the quality of these images is determined based on gamma correction using GLCM (Gray level co-occurrence matrix) by minimizing the homogeneity feature and by computing a global gamma value based on cumulative histogram without any knowledge of the imaging device. The performance of both the methods is compared in terms of metrics like MSE, PSNR & AMBE and it is illustrated that gamma correction based on GLCM by minimizing the homogeneity yields better results in terms of low MSE, high PSNR and low AMBE.

Keywords: panoramic radiography, contrast enhancement, gamma correction, GLCM, cumulative histogram.

1. INTRODUCTION

Panoramic radiography also called Panoramic X-ray is a two dimensional (2-D) dental X-ray that captures the entire mouth in a single image, including the teeth, upper & lower jaws, surrounding structures & tissues. Unlike other X-rays, where the film is placed inside the patient's mouth, the panoramic film is contained in a machine that moves around the patient‘s head. Large area of the jaws that cannot be seen with intraoral radiography can be visualized with panoramic. This makes these radiographs valuable for detecting impacted or supernumerary teeth, large pathologic lesions in the jaws and abnormalities in adjacent structures such as the maxillary sinuses. Also, they are valuable in the preliminary assessment of the implant site. A panoramic radiograph contains objects with a variety of texture and depth such as teeth and tongue. Because of this, luminance incident on the scene will be different. This change in illumination affects the visual appearance of the image. Hence a new automatic approach is needed for enhancing these X-ray images.

The imaging device applies the power-law transformation in each of the pixel image, hence Gamma correction is required to enhance each pixel of the image [7, 4].

A. Gamma Correction

The performance reliability of many computer vision is affected by the luminance incident on the scene. These illuminations usually have a nonlinear effect on the pixel values of the images. The luminance non-linearity introduced by the imaging devices is often described with simple point-wise operation called gamma correction. Gamma correction controls the overall brightness of an image. Gamma correction is used to compensate for the nonlinear behavior of a display device [1, 5]. Most often images are already encoded in gamma corrected form, and will appear fine when displayed on monitors.

The image of each pixel of the image has a nonlinear effect on luminance:

$$g(u)=u^{\gamma} \quad (1)$$

$u \in [0, 1]$ denotes the image pixel intensity is a positive constant introducing the gamma value. However, if an image is stored with a linear scaling it becomes necessary to correct the image. If the value of the gamma of the display device is known, then the correction process consists of applying the inverse of the above equation .i.e.,

$$g^{-1}(u)=u^{1/\gamma} \quad (2)$$

A number of gamma correction methods are implemented in the form of real-time hardware devices. They apply calibration parameters to image pixels before saving the output of the sensor. But often such calibration is not available or direct access to the imaging device is not possible. Also, many digital cameras dynamically vary the amount of gamma. Hence an algorithm is needed to reduce the effects of these nonlinearities without any knowledge about the imaging device. A proper estimation of gamma value enhances the contrast of the image [3].

2. PROPOSED TECHNIQUES

The proposed enhancement algorithm is done by using two methods. They are Gamma correction based on cumulative histogram and Gamma correction based on Gray Level Co-occurrence Matrix (GLCM) by minimizing homogeneity. The co-occurrence matrix is used to find the image details for better gamma estimation. The procedures of both the methods are explained in the following sections.

A. Gamma correction based on cumulative histogram

A proper estimation of gamma value enhances the contrast of the image.In this method, the gamma value is automatically computed based on the cumulative histogram [11].

The cumulative histogram C of the image is computed from equations (3) and (4)

$$his\ (r_k) = n_k \tag{3}$$

Where r_k is the intensity value n_k is the number of pixels in the image with intensity r_k, $his(r_k)$ is the histogram of the image with gray level r_k

$$C(h_j) = \sum_{j=1}^{k} his(r_j) \tag{4}$$

Where k is the gray level of an image, his (r_j) is the number of pixel in the j^{th} gray level, $C(h_j)$ is the cumulative histogram value for the j^{th} gray level.

Find the minimum, maximum and median values in the range C5 and C95. Calculate g using equation (5)

$$g = \log\left(\frac{median - minimum}{maximum - median}\right) \tag{5}$$

Normalize g value by eqn. (6).

$$g = \begin{cases} 0.8 \text{ if } g < 0.8 \\ 1.2 \text{ if } g > 1.2 \\ g \text{ otherwise} \end{cases} \tag{6}$$

Apply gamma correction in the input image. The normalized g value is used to enhance the contrast of the image by eqn. (7)

$$G(x,y) = (f(x,y))^{1/g} \tag{7}$$

B. Gamma correction based on Gray Level Co-occurrence Matrix (GLCM)

A novel method of gamma correction is adopted to enhance the contrast of the panoramic X-ray images. The image is divided into non-overlapping windows. To find the gamma value for each window, apply a range of inverse gamma values from 0.1 to 3 intervals in increments of 0.1 [2, 6]. Thirty images with different gamma value are obtained. Different windows may need a different gamma value for a proper enhancement. The gamma value of each window is estimated by minimizing the homogeneity of the gray level co-occurrence matrix (GLCM). This feature indicates how details of objects are visible in the image; the lower the value of this feature represents more visibility of the image details.

By using the homogeneity feature of the co-occurrence matrix to measure the visibility of image details, a proper gamma value will be assigned to each window. To find the best gamma value for each window, the co-occurrence matrix of each window is computed and the homogeneity feature is extracted. The gamma value associated with minimum homogeneity provides the best gamma value for enhancement. Homogeneity returns a value that measures the closeness of the distribution of elements in the GLCM to the GLCM diagonal and the range will be in [0 1].

1) Gray Level Co-occurrence Matrix (GLCM)

The Gray Level Co-occurrence Matrix (GLCM) method is a way of extracting second order statistical texture features that contain information about the positions of pixels having similar gray level values [8]. The GLCM is created from a grayscale image. The GLCM calculates how often a pixel with gray-level (grayscale intensity) value i occurs either horizontally, vertically or diagonally to adjacent pixels with the value j.

The basic GLCM algorithm is as follows:

1. Count all pairs of pixels in which the first pixel has a value i, and its matching pair displaced from the first pixel by d has a value of j.
2. This count is entered in the i^{th} row and j^{th} column of the matrix Pd[i,j]
3. Note that Pd[i,j] is not symmetric, since the number of pairs of pixels having gray levels[i,j]does not necessarily equal the number of pixel pairs having gray levels [j,i].
4. The elements of Pd[i,j] are normalized by dividing each entry by the total number of pixel pairs.

The minimum homogeneity feature is extracted from the co-occurrence matrix. The gamma value associated with minimum homogeneity provides the best gamma value for enhancement. Homogeneity returns a value that measures the closeness of the distribution of elements in the GLCM to the GLCM diagonal and the range will be in [0 1]. The enhanced image is obtained by applying this gamma value in the input image.

3. EXPERIMENTAL RESULTS

The objective of the paper is to establish an optimal algorithm for image enhancement for panoramic X-ray images. The images considered are panoramic dental x-ray image and the cameraman image. To test the accuracy of the proposed algorithms, the Panoramic X-ray image is taken as an input. The proposed algorithms of contrast enhancement are implemented on input images. To estimate the quality of reconstructed image, the performance metrics like Mean Square Error (MSE), Peak ignal to Noise Ratio(PSNR) and AMBE(Average mean brightness error) are analyzed.

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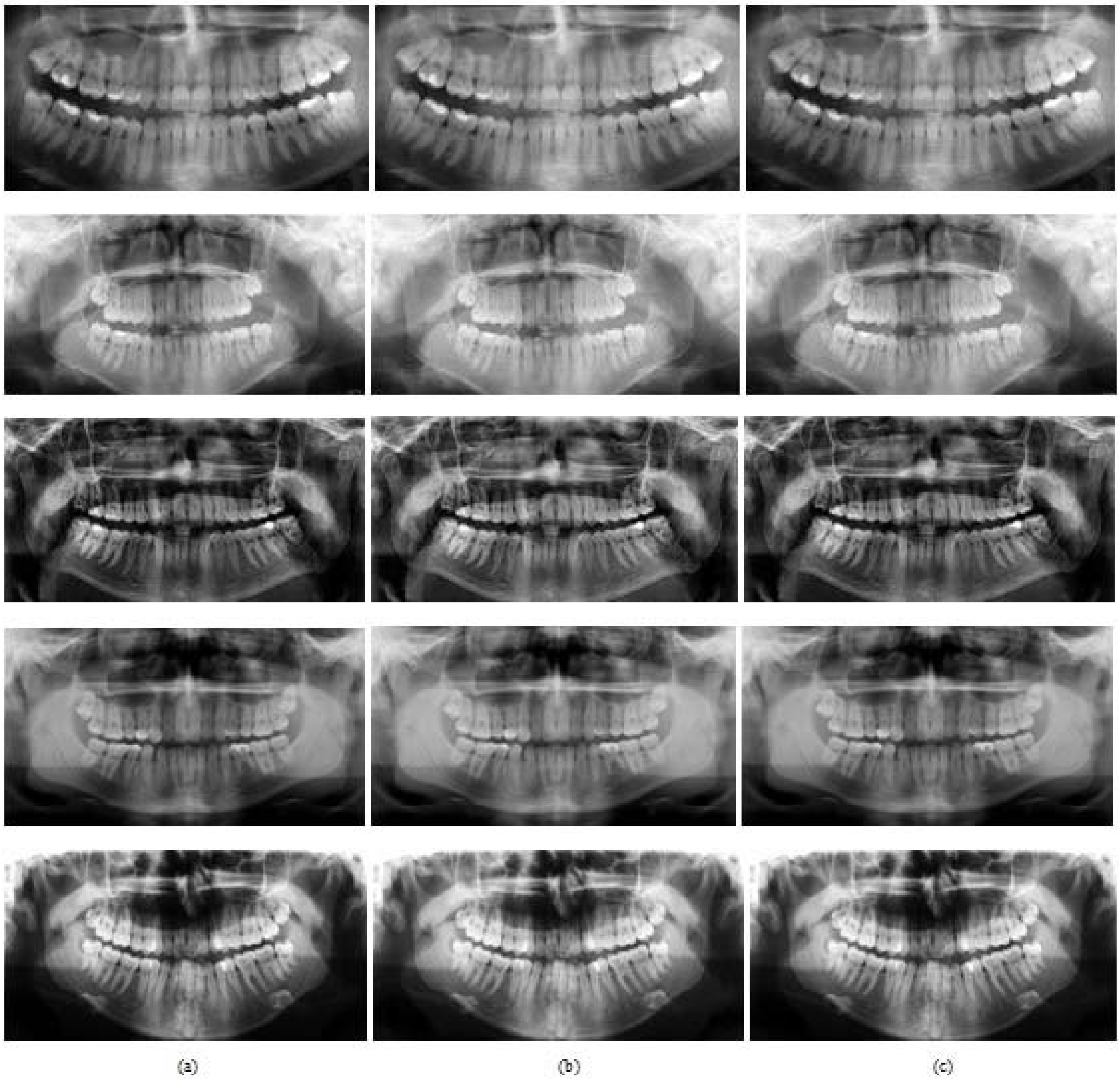

Figure-1. Panoramic Dental X-ray Images. (a) Original Images (b) Gamma correction based on Cumulative histogram γ=0.8 (c)Gamma correction GLCM Minimum Homogeneity γ = 0.8983.

Table-1. Comparison table - MSE, PSNR and AMBE.

Images fig. 1.(a)	MSE		PSNR		AMBE	
	Gamma correction Based on Cumulative histogram γ=0.8	**GLCM-Minimum Homogeneity γ=0.8983**	**Gamma correction based on Cumulative histogram γ=0.8**	**GLCM-Minimum Homogeneity γ=0.8983**	**Gamma correction based on Cumulative histogram γ=0.8**	**GLCM-Minimum Homogeneity γ=0.8983**
Image 1	337.4294	78.7456	22.8490	29.1685	18.0354	8.7039
Image 2	277.4963	65.6419	23.6982	29.9590	15.8903	7.7361
Image 3	321.3848	72.8461	23.0606	29.5067	17.3552	8.2292
Image 4	310.2952	71.9499	23.2131	29.5605	16.7795	8.0615
Image 5	239.6227	55.0362	24.3355	30.7243	13.9792	6.6610

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4. PERFORMANCE ANALYSIS

The quality of an image needs to be quantified. Optimizing the performance of digital imaging systems with respect to a wide variety of distortions during acquisition, processing, storage, transmission and reproduction, any of which may result in a degradation of visual quality [14]. So, measurement of image quality is very important to numerous image processing applications [10]. It can also be used to compare and evaluate image processing systems and algorithms. The performance of the proposed method is analyzed objectively by PSNR, MSE and AMBE.

$$PSNR=10*\log_{10}(255/MSE) \quad (8)$$

$$MSE = 1/mn \sum_{i=0}^{m-1}\sum_{j=0}^{n-1} [I(i,j) - k(i,j)]^2 \quad (9)$$

$$AMBE = |X' - Y'| \quad (10)$$

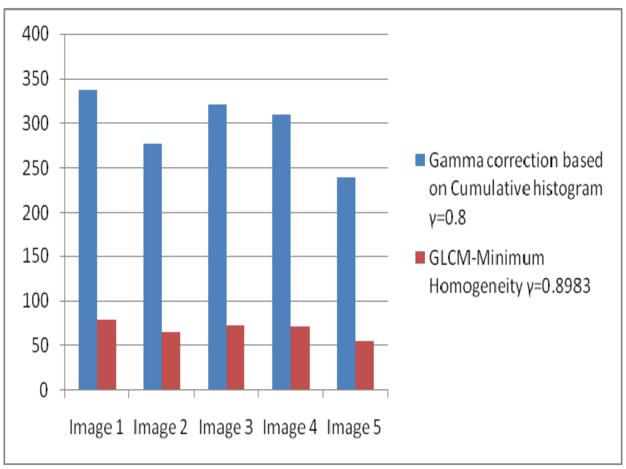

Figure-2. Comparison of MSE.

PSNR is used to measure the quality between the original and noisy image. MSE measures the cumulative squared error between the original and noisy image. The AMBE (Average mean brightness error) is basically used to measure the capability of the method to maintain the mean brightness of the input image in its output image where X and Y are the average intensity values of the input and output image respectively.

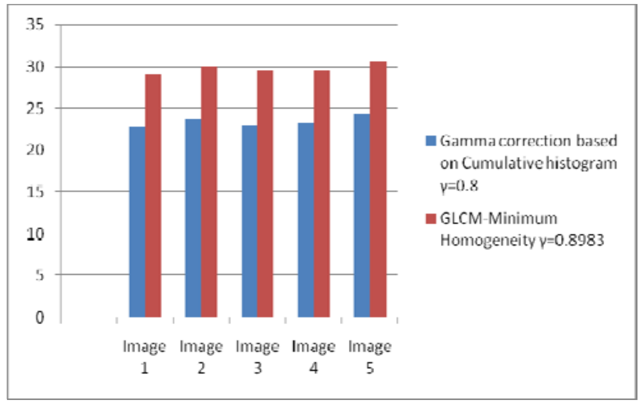

Figure-3. Comparison of PSNR.

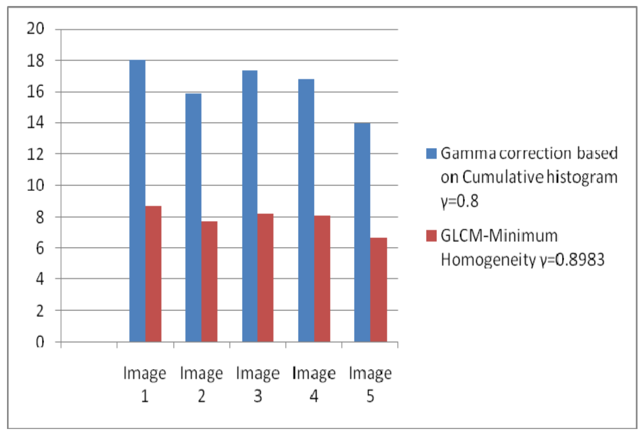

Figure-4. Comparison of AMBE.

A good enhancement method should have a low MSE and AMBE value and high PSNR value [12]. From table1,the gamma correction based on Gray Level Co-occurrence Matrix (GLCM) method by minimizing homogeneity yields better results compared to the other methods.

5. CONCLUSIONS

This paper addresses the problem of enhancing the panoramic dental X-ray images which suffer from different illumination that affects the visual appearance of the scene. In this approach, the image enhancement is based on gamma correction based on minimizing the homogeneity in GLCM matrix and gamma correction based on the computing cumulative histogram. The experimental results and performance analysis show the effectiveness of gamma correction method based on GLCM matrix compared to the gamma correction method based on the cumulative histogram as it produces low MSE, high PSNR and low AMBE. This work can be further extended to find a novel enhancement method that still improves the quantitative measures.

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REFERENCES

[1] Shipra Suman., Fawnizu Azmadi Hussin. Image enhancement using Geometric mean filter and Gamma correction for WCE images. Springer International Publishing Switzerland.276-283, 2014.

[2] Xu Guan Traffic & Transp. Coll., Jilin Univ., Changchun, China Su Jian ; Pan Hongda ; Zhang Zhiguo ; Gong Haibin, "An Image Enhancement Method based on Gamma Correction" , IEEE, Computational Intelligence and Design, P.60-63, Dec 2009.

[3] S. Gayathri., N. Mohanapriya., B. Kalaavathi., Efficient Contrast Enhancement using Gamma Correction with Multilevel Thresholding and Probability based Entropy. IJRET, Volume: 03 Special Issue: 07, May 2014.

[4] Seema Rani., Manoj Kumar. Contrast Enhancement using Improved Adaptive Gamma Correction with Weighting Distribution Technique. International Journal of Computer Applications. Volume 101 - Number 11, 2014.

[5] Hassanpour H., Asadi Amiri S. Image quality enhancement using pixel wise gamma correction via SVM classifier. International Journal of Engineering, 24, 301-311, 2011.

[6] Asadi Amiri S., Hassan pour H., Pouyan A.K. Texture based image enhancement using gamma correction, J. Scientific Research, 6, 569-574,2010.

[7] Farid H. Blind inverse gamma correction. in Proc, IEEE Transactions on Image Processing. 10, 1428-1433, 2001.

[8] Park B. and Chen Y. R. Co-occurrence Matrix Texture Features of Multi-spectral Images on Poultry Carcasses. Automation and Emerging Technologies. Vol.78, No.2, 27-139, 2001.

[9] Haralick R. M., Shanmugan K. and Dinstein I. Textural features for image classification. IEEE Trans. SMC, Vol. 3, 610–621.1973.

[10] Wang Z., Bovik A. C., Sheikh H. R. and Simoncelli E. P. Image quality assessment: From error visibility to structural similarity. IEEE Transactions on Image Processing, Vol. 13, No. 4, 600-612, 2002.

[11] C.C. Sun., S.J. Ruan., M.C. Shie. and T.W. Pai. Dynamic Contrast enhancement based on Histogram Specification. IEEE Consum. Electr, 49, 1300-1305, 2005.

[12] Gonzalez R. C., Woods R. E. Digital image processing. Prentice Hall, Upper Saddle River, 2002.

[13] Chen Q., Xu X., Sun Q., Xia D. A solution to the deficiencies of image enhancement. J. Signal Processing. 44-56, 2010.

[14]Gastaldo P., Zunino R., Heynderickx I., Vicario E. Objective quality assessment of displayed images by using neural networks. J. Signal Processing, Image Communication. 643-661, 2005.