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Contrast Enhancement of Multi Root Teeth CBCT Image for Endodontic Therapy

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Abstract: Healthy teeth means healthy roots because root of tooth is an important part of the body; it not only holds the tooth in jawbone but also keeps the jawbone healthy. Mostly bacterial infection in pulp damages the strength of roots. Because pulp is the only living part of the structure inside the root. Due to this teeth lose occurs in early ages. Hence, accurate evaluation of the root canal anatomy is required to keep your teeth healthy. For that endodontic therapy is the best treatment. In endodontic therapy, clear understanding of the root features is required. In this proposed work, CBCT image enchantment is done to get the features for endodontic therapy. The algorithm includes multi-scale retinex method and fuzzy enhancement approach to enhance the CBCT dental image without losing the important medical information of the original image. This methods compare with tradition histogram and Contrast limited adaptive histogram equalization CLAHE method .Comparison of the outputs have been calculating in term of peak signal to noise ratio (PSNR). The results have been encouraging; moreover the proposed method can be implemented in the treatment, planning and follow up of the endodontic.

Keywords: CBCT Image, Contrast Enhancement, Multi Root teeth, Endodontic Therapy.

I. INTRODUCTION

In human body anatomy jawbone play an important role, it hold the teeth. For healthy teeth, the root of teeth should be maintained well and strong. Tooth loss occurs due to the bacterial infection in pulp, which is present in the root. Root canal treatment is very important to preserve the tooth. Hence, accurate evaluation of dental image is necessary and crucial for the diagnosis of diseases. Correct and exact dental image diagnosis is the most essential part of dental treatment [1]. Dentists often face challenges in perceptions, contrast and quality of dental images. Many times endodontic lesions show symptoms that are very similar to those of other problems [2]. One of the challenging scenarios in endodontic therapy is that the lesion is not visible from the outer side until a 3D image technique is used for the follow up; it is hazardous for doctors to diagnose with preconceptions [3].Understanding of teeth morphology is very important for root canal or endodontic therapy. The expert has to be completely familiar with the anatomy of the root .Without knowing the structure of the teeth and the root, successful debridement and obturation is not possible [4]. Therefore, the conception of entire root canal system has to be distinctly understood. A procedure of cleaning and shaping the system should be employed properly to address the anastomoses and the canals, else the infection would leave in the canal system due that diagnosis may fail. During the endodontic therapy, the root length plays a very important role for the surgery. The length of the root tells the depth upto which the root is present. If the root length is known properly and correctly, then the surgery can be done correctly without any problem, and the endodontic therapy can be successfully impemented.

The maxillary central incisors have one canal and it tends to curve towards the third apical level which might appear straight and attenuating [5]. The maxillary lateral incisors are short as compared to the former and have very thin walls with a fine canal. The longest tooth is maxillary canine which consists of a narrowing at 2-3mm. This narrowing leads to danger of over-instrumentation if a large file is utilized at the level. The length of the root is difficult to find as the apex curves labially and the tooth appears shorter than the actual length. The teeth which have two roots, maxillary first premolar is the most difficult to treat [6]. It has very delicate roots and they may curve at apical third, therefore

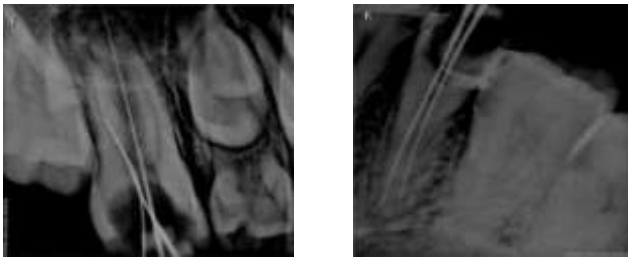
instrumentation has to be performed very carefully. Hence, the morphology of the tooth has to be understood very clearly and carefully. For that image processing techniques are the robust solution to enhance features of CBCT dental image.

Many papers have been listed for CBCT images enhancement using different techniques and approaches[7,8]. Fuzzy and morphology based approach has been applied for metal artifact reduction from dental CBCT image[9].In that metal reflection problem is addresses . Several histrogram based and bi histrogram contrast enhancement techniques have been applied on the dental CBCT images[10,11].The previous work displays quite interesting results, however, there is still a requirement for better results and more accurate algorithms. In order to improve the quality of the images and feature enhancement, proposed multi scale retinex method is used for improvement of the CBCT dental image without any degradation of important features of the original dental images.

The remaining work has been categorized in the following sections. The next section details about the endodontic therapy. The proposed method for the work is demonstrated in Section III. The Section IV displays the experimental results and observations followed by the conclusions as well as future works in Section V.

II. ENDODONTIC THERAPY

Root of tooth is very small and thin area which cannot be visuliase without enhancing the medical image .Some time multi root of tooth is critical scenario for endodontic treatment, which has to be handle carefully. Endodontic Treatment involves the diagnosis of the infected pulp by cleaning, shaping, decontamination and filling of the canal which helps in the removal of the infection and protection of the tooth from microbial infection. This treatment requires a clear image feature of the tooth anatomy. Many of teeth morphology have multiple roots or some roots are superimposed which looks like a single root. Figure 1 displays dental images with multiple roots in which figure 1 (a) shows the CBCT image of tooth with triple roots and figure 1(b) shows the decayed tooth with double roots [12]. These multi roots of teeth mislead the endodontic treatment. These challenges can be handled by enhancing the feature during the imaging of teeth for which image processing techniques are viable solutions.



(a) (b)

Figure.1 CBCT dental images with multiple roots

III. METHODOLOGY

A. Multi Scale Retinex Method

The proposed algorithm is used for enhancement of the CBCT dental image to get the clear feature for endodontic therapy. This method involves multi-scale retinex algorithm which refers to the weighted addition of the outputs of single scale retinex.

$$R_{MSR_i} = \sum_{n=1}^{N} \omega_n R_{n_i} \quad (1)$$
$$= \sum_{n=1}^{N} \omega_n [\log I_i(x,y) - \log(F_n(x,y) * I_i(x,y))]$$

In equation (1) R_{MSR_i} Shows the multi scale retinex value which is the addition of weighted R_{n_i} single scale retinex. R_{n_i} Consists of I_i the input image on i^{th} colour channel, the subscript i Ɛ R, G, B which represents the three colour band. R_i is the retinex image, N is the number of scales, ω_n refers to the weights for each scale. Equation (2) shows the $F_n(x,y)$ value estimation.

$$F_n(x,y) = C_n e^{-(x^2+y^2)/2\sigma_n^2}, \quad (2)$$

In equation 2, σ is the filter standard deviation of the Gaussian distribution that determines the scale. It controls the amount of the spatial details that is retained and C represents a normalization factor such that $\int F(x,y)dxdy = 1$. The output involves trade-off between the enhancements of the local dynamics. The framework of Multi-Scale Retinex Method is shown in figure 2. Multi-scale retinex seems to offer a good tradeoff between dynamic range compression and rendition of the pixel intensity.

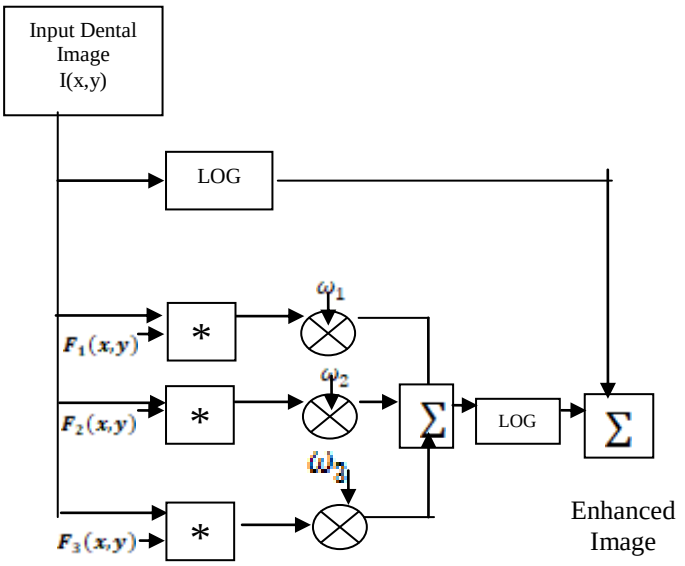


Figure.2 Framework of Multi-Scale Retinex Method for Enhancement of CBCT dental Images

B. Fuzzy Based Contrast Enhancement method

Fuzzy based image processing algorithm is very useful because it can handle the uncertainty in various application. Many Researchers are proposed algorithms which works on the concept of fuzzy logic [13, 14]. In proposed method, fuzzy approach is used for contrast enhancement of CBCT images. In This method for decreasing the dynamic range of image normalization is used .Then contrast mapping is done using equation 3.

$$I_{FuzzyCon} = \frac{|I_{Fuzzy} - I_{meanFuzzy}|^{\rho}}{|I_{Fuzzy} + I_{meanFuzzy} + \epsilon|^{\rho}} \quad (3)$$

Here, ρ is a fuzzy parameter which depends on the type of image. Then mapping of contrast means changing of low contrast to high contrast is done using fuzzy interference rule. For contrast mapping equation 4 is used.

$$I_{FuzzyCon} = \frac{1 - e^{-k \times I_{FuzzyCon}}}{1 - e^{-k}} \quad (4)$$

Where K is contrast mapping function which is depend on image parameter. Then enhanced image is achieved due to implementation of fuzziness rules.

IV. Experimental Results and Discussion

Proposed algorithms are implemented on different multi rooted dental CBCT Images. Four different roots dental CBCT images have been used that are shown in figure 3, 4, 5 and 6. The figure 3 depicts a dental image with single-rooted teeth. Figure 4 shows an example of pre-molar tooth with double roots. In the latter image the structures, gum area and the position of the tooth can be seen. An instance of tooth with triple roots is depicted in figure 5.In which all the roots are superimposed and are visible as a single root. Figure 6 shows CBCT image which is the decayed tooth with double root. This type of multi root of teeth leads confusion in diagnosis. These conditions needs to be analyzed and the treatment should be evaluated with proper processing.

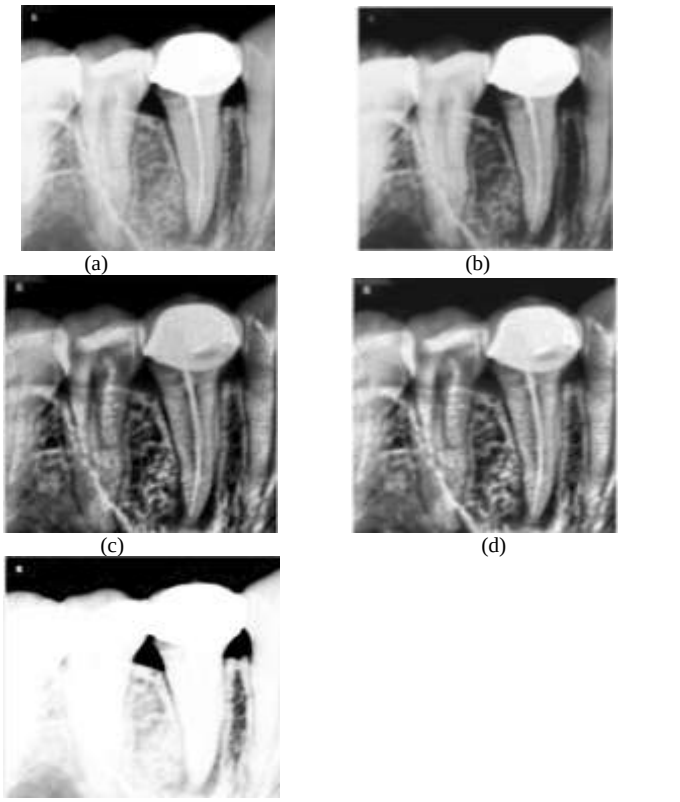
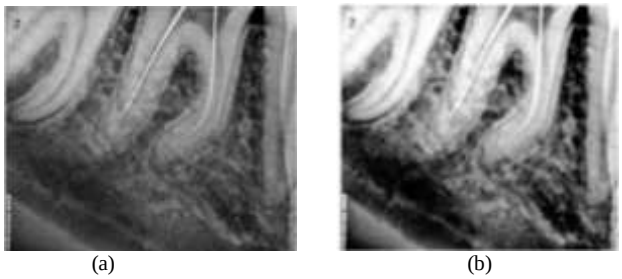
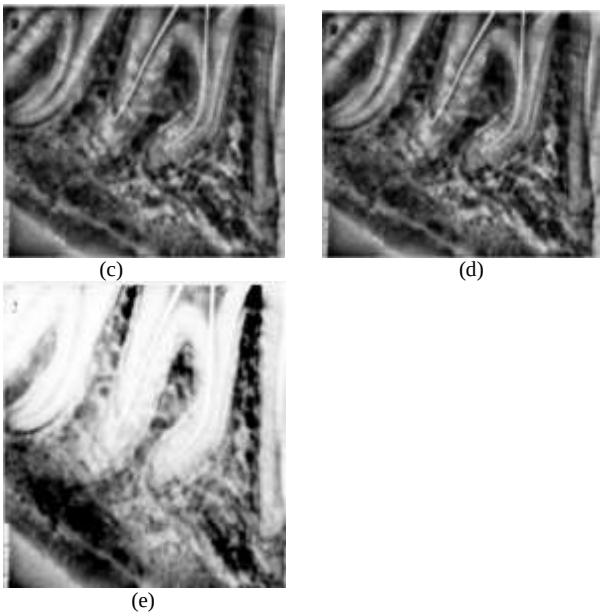


Figure 3 (a) Dental single –rooted CBCT input image (b) Output image after Histogram (c) Output image after CLAHE (d) Output after MSR (e) Output after Fuzzy enhancement.

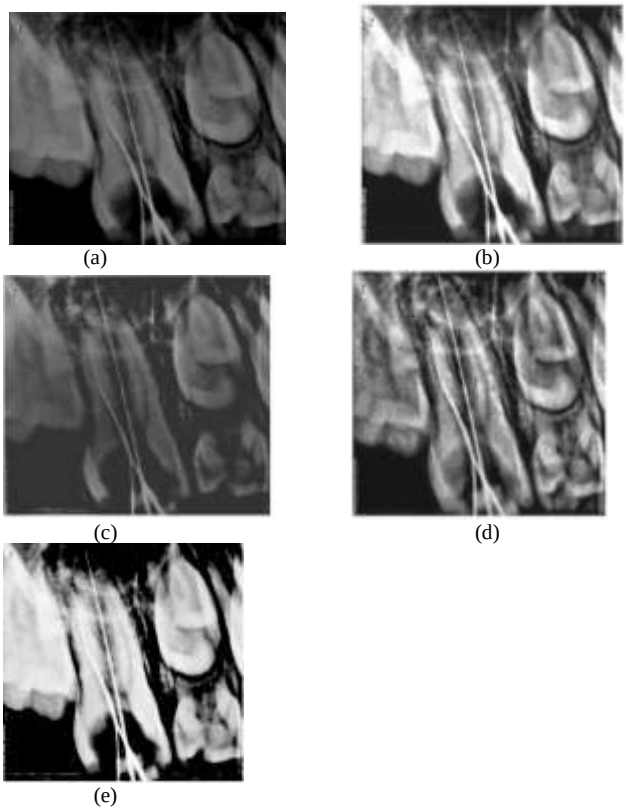




(c) (d) (e)

Figure 4 (a) Dental pre-molar tooth with double roots CBCT input image (b) Output image after Histogram (c) Output image after CLAHE (d) Output after MSR (e) Output after Fuzzy enhancement.

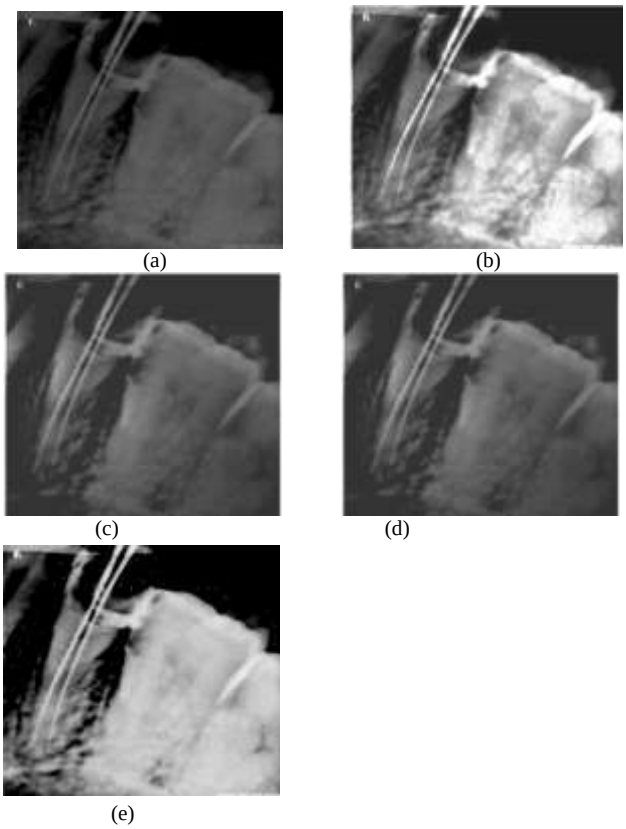
The input CBCT dental images have been evaluated using histogram equalization; contrast limited adaptive histogram, fuzzy enhancement method and multi scale retinex method. Figure 3(b), 4(b), 5(b) and 6(b) displays the output for histogram equalization. Contrast Limited Adaptive Histogram Equalization has also been performed on the input images which can be seen in the figure 3(c), 4(c), 5(c) and 6(c).



(a) (b) (c) (d) (e)

Figure 5 (a) Roots superimposed CBCT input image (b) Output image after Histogram (c) Output image after CLAHE (d) Output after MSR (e) Output after Fuzzy enhancement.

From Figure 3(d), 4(d), 5(d) and 6(d) shows four samples of the multi scale retinex output for the corresponding input dental images. It is clearly visible in the figure that the generated output is completely enhanced and is visually better than the input images. For endodontic treatment visual perception of root of tooth is the uttermost parameter which should not be neglected for planning of treatment. As the length width of the root is very narrow so enchantment of that portion is taken care in the proposed algorithm. Most of the histogram methods over enhance the intensity of pixel which may misled the diagnosis.



(a) (b) (c) (d) (e)

Figure 6 (a) Decayed tooth with double root CBCT input image (b) Output image after Histogram (c) Output image after CLAHE (d) Output after MSR (e) Output after Fuzzy enhancement.

From Figure 3(e), 4(e), 5(e) and 6(e) shows the output of fuzzy enhancement method of respective input multi root CBCT images. The visual quality of input images are improved. For quantitative assessment of the quality of images, Peak Signal to Noise Ratio has been calculated for the input and the enhanced dental image. Table I shows the PSNR value of

CBCT images for histogram equalization, contrast limited adaptive histogram, fuzzy enhancement and multi scale retinex method.

Table1. Comparative PSNR values for the Different Enchancement Techniques

IMAGE	Histogram PSNR	CLAHE PSNR	MSR PSNR	Fuzzy Enhancement PSNR
Dental Image 1	17.7462	15.3679	40.3654	91.61
Dental Image 2	16.3697	16.0663	45.6985	79.06
Dental Image 3	11.1211	14.1896	46.35214	75.93
Dental Image 4	9.8588	14.5934	44.2365	79.28

It can be observed from the table 1 that PSNR value for the fuzzy enhancement method is higher than other methods. Higher PSNR gives better visual perception of image. So, it is clearly visible from the output images that the CBCT dental image has been enhanced better by the proposed methodology.

V. CONCLUSION AND FUTURE WORK

Cone Beam Computed Tomography is in great demand for various dental image applications. CBCT enables to determine exact diagnosis and treatment for endodontic therapy. Being a low radiation image technique, it is also prone to degradation of the image. Hence, the proposed work has enabled to enhance the feature of the CBCT image for endodontic treatment. For feature enhancement of the CBCT dental image, Comparison of enhancement is done with various method like multi-scale retinex method, fuzzy based enhancement and histogram enhancement methods .The quality of the image has been assessed and the outputs have been compared by calculating the peak signal to noise ratio. The results have been encouraging and the proposed scheme can be implemented in the treatment, planning and follow up of the endodontic treatment. Furthermore, future work can include the extraction of the features from the enhanced image and the classification for various dental diseases.

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