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IDENTIFICATION OF PREPROCESSING TECHNIQUE FOR ENHANCEMENT OF DENTAL IMAGES

Engineering

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ABSTRACT

This paper presents an analysis and identification of image pre-processing techniques suitable for dental images. Pre-processing is one of the preliminary stages used for dental enhancement to aid dentists in dental procedures and diagnosis, and in post-mortem identification. Fourteen image pre-processing techniques are considered here for dental images. These pre-processing techniques are implemented using Matlab. The results obtained are compared on the basis of Peak Signal to Noise Ratio (PSNR) for a set of 60 dental images. A high value of PSNR indicates better suitability of the pre-processing technique for analysis of dental images using image processing. By using 2 way ANOVA, the results have been tested at significant level of 5%. The results shows that the interaction of pre-processing techniques with dental images on PSNR values is significant. By using K-means clustering it has been found that Power-law transformation and Adaptive median filter are giving better enhancement results in terms of achieved PSNR values as compared to other pre-processing techniques analyzed here. These identified pre-processing techniques, chosen carefully may give better results for further analysis of dental images and thereby giving quantitative and qualitative feedback to dental practitioners, for an early detection and diagnosis of dental diseases.

KEYWORDS:

Image Processing, Dental X-Rays, Image enhancement, PSNR.

INTRODUCTION

Some of the major applications of image processing are in the areas of biometric and bio medical image processing. Image enhancement is an important step in most if the image processing applications. Dental X-ray image analysis applications are important in helping dentist procedures and diagnosis, and in postmortem identification. In two decades we can find a great increase in the usage of digital dental X-rays because of many advantages such as these images are available immediately, the lower radiation dose, the possibility of image enhancement, image reconstruction and more importantly, digital dental X-rays make computer aided dental X-rays analysis possible and convenience.

The dental radiograph can be divided into teeth areas (having highest intensity), Bone areas (having average intensity) and background area (having lowest intensity). It is difficult to distinguish between teeth and bone areas as their intensities are more or less alike in cases of uneven exposure. Hence a good enhancement technique is required to do analysis of dental images. Image enhancement may include manipulation of image intensity and contrast, reducing the levels of noise present, background removal in order to avoid any artifacts, edge sharpening, filtering etc. Pre-processing of dental images is essential for increasing the contrast between image background and tooth and to sharpen the edges or boundaries of suspected caries lesions. In this paper fourteen pre-processing techniques are tested for better suitability of enhancement of dental images

REVIEW OF RELATED WORK

Radiographs helps in diagnosis of many dental anomalies otherwise it would be impossible to find their location in the mineralized tissues (bone and teeth) that cannot be seen during a visual examination in dental practices. The use of radiographs is necessary during the treatment phase, e.g., during root canal treatment to monitor the progress of the root preparation, or to know the orientation of wisdom molars to be extracted. The effect of dental treatment of bony structures, e.g., the treatment of periodontal defects can be established by radiographic examination only [1].

As compared with other types of images, dental X-rays analysis is a challenging problem for image processing methods due to the following reasons: (1) poor image modalities: noise, low contrast, and sampling artifacts; (2) complicated topology; (3) arbitrary teeth orientation; and (4) lack of clear lines of demarcation between regions of interest, which is especially true for dental X-rays since problem teeth tend to have very complicated structures and are normally coupled with healthy teeth. Dental X-rays are normally inspected by a dentist. Although efficient, human inspection requires specialized training and a dentist's time, which are expensive. Moreover, human inspection may vary from dentist to dentist, and, as such, does not give a quantitative measurement. Also, some early lesions may not be even visible to the human eye, if they are located in between teeth. . All of these issues indicate a need for effective method for dental X-rays analysis [1].

Besides being used for clinical diagnosis, dental X-rays are also widely used in forensic identification. Forensic dentistry involves the identification of people based on their dental records, which mainly available in the form of radiograph images. Jain et al. [2–5] are doing research work on an automatic human identification system using dental X-rays. In the domain of dentistry the diagnosis of dental diseases from digital dental x-rays is being beneficial and helpful for both doctor as well as patient. Histogram equalization is the distribution of intensity of pixels throughout the image to achieve the higher and required contrast [6]. Qaramaleki et al. used gamma correction to enhance image quality and to diagnose secondary caries on dental radiography images [7].

Morphology could be used as a tool for image processing by extracting and representing regions and shapes of objects in images. The application areas of morphology are Image enhancement, detection and segmentation of objects [8][9][10]. There are two simple morphological operations called erosion and dilation on the basis of which a large number of filters can be designed. Solanki et al. applied Top-hat and bottom-hat filters to the original image to achieve enhancement and they have applied edge detection to inspect the depth of dental caries in cases of decayed tooth [11]. EyadHaj Said et al. performed gray scale stretching transformation for enhancement, top-hat and bottom-hat filters for segmentation and Morphological filtering like 2-D modified wavelet kernels to detect boundaries of individual tooth [12]. Bardia Yousefi et al. improved the visibility of digital dental x-ray for teeth, bone and canals using morphological operation [13]. P.L. Lin et al. proposed a dental classification to effectively segment, classify, and number teeth in dental bitewing radiographs. In this work an image enhancement method that combines homomorphic filtering, homogeneity based contrast stretching, and adaptive morphological transformation is proposed to improve both contrast and illumination evenness of the radiographs [14].

Median filter is a special case of non-linear filters used for smoothing images. Nowadays median filters are being used in smoothing and reducing noise of dental X-Ray images [15][16]. Ingrid Nurtanio et al. proposed the Gaussian filter to remove noise and smoothing of dental panoramic images [17].

IMAGE PREPROCESSING TECHNIQUES

In this paper, we report on suitable pre-processing technique for identification of dental caries lesions in X-Ray images. Numerous approaches for image enhancements are available. It includes Histogram Equalization, adaptive Histogram Equalization, Median filtering, Adaptive median filter, mean filter, morphological processing, anisotropic distortion, bilateral enhancement, unsharp masking, homomorphic filtering, weiner filter, Gaussian filter, High boost filtering and Power-law transformation.

The intensity of light generated by a physical device is not a linear function of the applied signal. This non-linearity must be compensated in order to achieve correct reproduction of intensity. Power law transformation or Gamma correction is used to compensate for the transfer characteristics of each capturing and display devices. It maps a narrow range of dark input values into a wider range of output values. It is mathematically expressed as (1)

$$s = C\, r^{\gamma} \qquad \text{----------} \qquad (1)$$

Where r is the input grey level, s is the output grey level, C is the constant and γ is the correction factor. By varying γ, it is possible to get different enhancement levels.For a typical dental image considered in this contest, Power-law transformation is giving a highest value of PSNR for $\gamma = 0.994$. The figure 1 shows the variation of PSNR Values for different values of γ for a dental image.

Median Filter not only reduces the noise present in the image but also preserves useful information present in the image. It is a nonlinear filter which is usually used to remove the impulsive noise in a image. In the present work, Median filter and adaptive median filter mask size of 3x3 is considered. Gaussian filters are very useful in smoothing as well as in removing noise drawn from normal distribution. The Gaussian filter in the continuous space is given by (2)

$$h(m,n) = \frac{1}{\sqrt{2\pi}\sigma} e^{\frac{m^2}{2\sigma^2}} \times \frac{1}{\sqrt{2\pi}\sigma} e^{\frac{n^2}{2\sigma^2}} \text{ ------ } (2)$$

where σ is the standard deviation. Weiner filter restores the image in the presence of blur as well as noise. It works very well for specific applications and it is not suitable for general images. It is an optimum filter which tries to build an estimate of the original image by enforcing a minimum mean square error constraint between estimate and the original image. The minimized error is given by (3)

$$e^2 = E\{f(x,y) - \bar{f}(x,y)\} \qquad \text{-------} \qquad (3)$$

where E is the expectation.

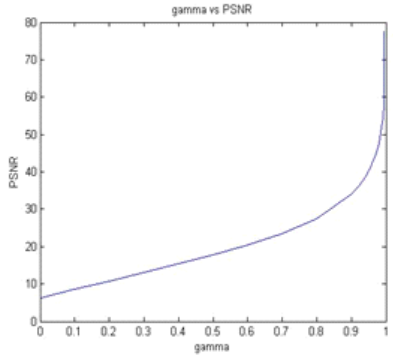

Figure 1: PSNR vs. gamma for a dental image using Power law transformation

RESULTS AND DISCUSSION

The pre-processing techniques described in section III have been implemented using Matlab on a set of 60 images A high value of PSNR indicates better suitability of the pre-processing technique for analysis of dental images using image processing. PSNR has been calculated for comparison of these techniques. PSNR reading of 60 images were recorded for all the fourteen pre-processing techniques. Average, minimum and maximum PSNR values obtained for a set of 60 dental images are listed in Table 1. Power law Transformation, Adaptive median filter, Median filter, Gaussian filter, and Weiner filter are having higher values of PSNR and hence giving better enhancement results as compared to other pre-processing techniques analyzed here. Figure 2 shows a bar graph showing average PSNR values in dB and maximum and minimum values of PSNR for different pre-processing techniques. Figure 3(b) to figure 3(o) shows enhanced image for different pre-processing techniques for a dental image shown in figure 3(a).

The statistical analysis is carried out using data analysis pack of Microsoft Excel by using 2 way ANOVA, the results have been tested at significant level of 5%. The metric used to measure the accuracy of the pre-processing techniques was the PSNR. The result of 2 way ANOVA is shown in Table 2. The result shows that two factors i.e., pre-processing techniques (columns) and dental images (rows) are significant, which means that the enhancement techniques act differently and different images are affected differently and the interaction of preprocessing techniques with dental images on PSNR values is significant.

The accuracy of the result is also tested using box plot as shown in figure 4. Results clearly help in identifying Power law transformation is better suited pre-processing techniques for dental images. The results also verified using K-means clustering as shown in Table 3. It shows that Power-law-transformation is best suited pre-processing technique for dental images followed by adaptive median filter, median filter, Gaussian filter, wiener filter.

TABLE 1. AVERAGE, MINIMUM AND MAXIMUM PSNR VALUES

Sl No.	Preprocessing Technique	PSNR Values (in dB)		
		Average	Max	Min
1	Adaptive Histogram Equalization	15.42138	17.6296	11.4423
2	Homomorphic Filtering	12.8636	17.6296	9.3798
3	Unsharp Masking	33.2748	37.1859	30.0318
4	Mean Filter	34.2343	43.7331	30.3227
5	Median Filtering	49.1214	51.9736	45.7437
6	Power Law transformation	57.3970	63.7074	49.6108
7	Histogram Equalization	14.9890	21.6010	9.1661
8	Gaussian Filter	45.9288	53.9036	43.5935
9	Morphological Processing	31.4202	34.8376	27.9958
10	Weiner Filter	40.2514	43.8542	36.2229
11	Anisotropic Diffusion	39.3672	41.7961	35.7185
12	Bilateral enhancement	22.9068	26.123	20.3034
13	Adaptive Median Filtering	51.32376	53.8793	49.2881
14	High Boost Filter	14.007	26.123	20.3034

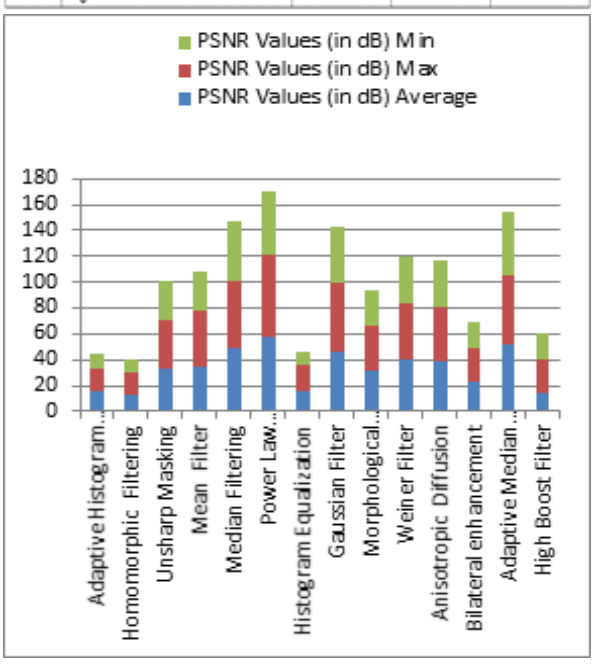

Figure 2: Average PSNR values, maximum and minimum PSNR values for various pre-processing techniques.

Table 2 The Two way ANOVA Table indicating the interaction of enhancement techniques with dental images for P<.05

ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Rows	413.5717	59	7.00969	1.839416	0.000205	1.338736
Columns	177451.4	13	13650.1	3581.93	0	1.73292
Error	2922.902	767	3.810824			
Total	180787.8	839				

Table 3 K-means clustering result

Sl. No.	Final Cluster Centers					
		Cluster				
	TECHNIQUES	1	2	3	4	5
1	AHE	20.54	18.2334	15.31431	13.05814	15.99
2	HOMO	10.45382	9.3798	13.14621	14.05197	11.88
3	UNMASK	31.33494	35.8323	33.69164	34.05054	31.39
4	MEAN	36.57907	43.7331	33.40088	33.38089	35.32
5	MEDIAN	50.35526	48.7113	49.31937	48.9152	47.37
6	POWER LAW TRANSFORMATION	53.30304	52.4439	56.97192	60.59625	54.19
7	HISTEQ	15.19813	9.1661	17.74001	12.06463	16.28
8	GAUSSIAN	48.14248	53.9036	45.40606	44.89477	46.28
9	MORPHO	33.19056	30.2463	31.77013	30.9595	29.37
10	WEINER	42.39601	39.4186	40.2956	39.93233	38.18
11	ANISOTROPIC	40.32067	37.7123	39.68642	39.2495	37.47
12	BILATERAL	24.5042	22.1553	22.7743	22.65083	21.74
13	ADAMED	52.25338	53.8504	51.25075	51.0651	50.72
14	HIGHBOOST	16.04033	20.1602	14.05424	12.65614	14.71

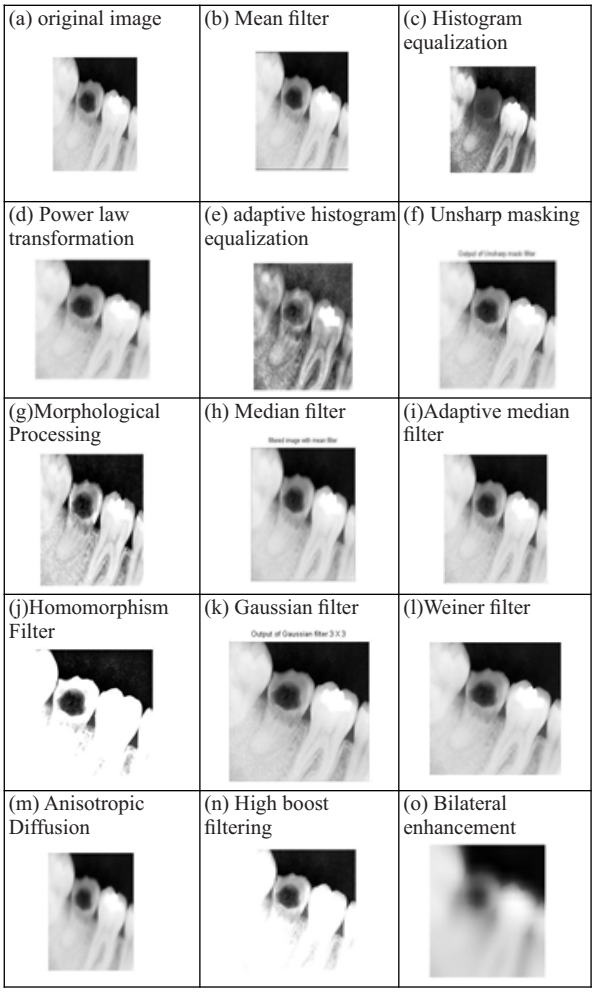

Figure 3: Original image and output of various pre-processing techniques for a dental image pre-processing techniques

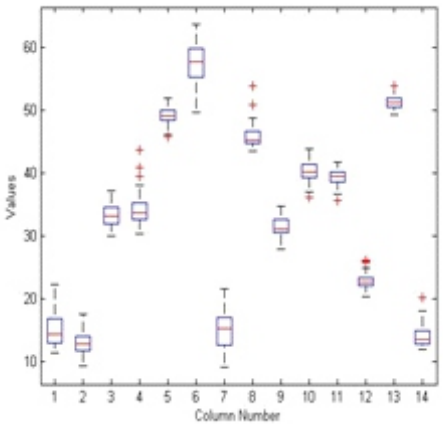

Figure 4: Box plot showing the performances of each pre-processing techniques

CONCLUSION

In this paper, fourteen image pre-processing techniques namely power law transformation, histogram equalization, adaptive histogram equalization, mean filter, median filter, adaptive median filter, Gaussian filter, wiener filter, high boost filter, unsharp masking, Homomorphic filter, morphological processing and Anisotropic diffusion have been considered to identify its better suitability to dental images. These pre-processing techniques have been tested on a set of 60 images and the result shows that Power law transformation, adaptive median filter and median filter are giving better PSNR values followed by Gaussian filter and wiener filter. The validity of the result is checked using two way ANOVA at significant level of 5%. By the result of K-means clustering, we can conclude that Power-law transformation technique is best suited for enhancement of dental images. But in the method, in order to get better result , gamma value is to be set for the suitable value. The identified pre-processing techniques may be followed by segmentation, texture analysis, feature extraction and classification to yield better results. The future scope is to use the identified enhancement techniques in dental procedures and diagnosis and in postmortem identification.

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