Scientific Journal of Impact Factor(SJIF): 3.134
e-ISSN(O): 2348-4470
p-ISSN(P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 2,Issue 6, June -2015

COMPARATIVE ANALYSIS OF CANNY AND ISEF ALGORITHMS FOR CARIES AFFECTED TOOTH

A J Solanki[1], B J Jadawala[2]

[1]*Electronics &CommunicationEngg., B&B Inst. Of Tech*
.[2]*Electronics &CommunicationEngg., B&B Inst. Of Tech.,*

Abstract— *Dental image processing is one of the emerging fields in case of human identification in forensic sciences. Dental x-rays have been quiet effective for the diagnosis and detection of problems in tooth. This paper presents an add on approach in the same area of medical biometrics to detect and diagnose the dental caries in case of decayed tooth. The enhancement and segmentation of digital dental x-ray image is done by using Infinite Symmetric Exponential filter (Shen Castan Algorithm) and Canny's Gaussian filter. The aim of this paper will be to provide comparative analysis between two edge detection techniques, Canny and Infinite Symmetric Exponential filter. After deciding the best edge detection technique from the above two, we will extract the caries affected tooth and decide the dental treatment like filling or Root Canal Treatment.*

Keyword: *Lesion, Enamel, RCT, caries, dentine, pulp, ISEF, dental radiograph, dentistry, Canny edge detection algorithm*

I. INTRODUCTION

The process of extracting features, collecting & analysing the useful image information for clinical diagnostics of teeth is the prime need of today's medical science [1]. In this domain of dental image processing, most of the research done is beneficial for forensic science experts for the purpose of human identification. Moving a step ahead in this 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. Bardia Yousefi et al. in 2012 improved the visibility of digital dental x-ray for teeth, bone and canals using Laplacian transform along with morphological operation. Wavelet transforms and Bayesian classifier is used to classify teeth and canals from resultant image [2]. Ştefan Oprea et al. in 2008 performed dental caries classification based on the edge detection. The dental x-ray image is segmented into individual tooth and then it is converted into binary image of the tooth. The edge detection gives the outline of the dental cavity. The number of carries affected pixels is determined. The carries is classified as *pulpal* if black caries region is adjacent to the white border enclosing the tooth. If there exists two or more number of black regions and the width of the black region is less than 2 *mm* then it is *Enamel* carry [3].

Prof. G.A. Kulkarni et al. in 2011 proposed two degree differential gray scale method for dental image recognition. The two degree differential method isolated the un-matched part of the two images and gave a satisfied similar rate when the matching location was found. If the matching location was not found, this method enhanced the difference and reduced the similar rate [1]. EyadHaj Said et al. in 2008 performed gray scale stretching transformation for enhancement. Morphological filtering like top-hat and bottom-hat filters were used for segmentation. 2-D modified wavelet kernels were used to detect boundaries of individual tooth [4].

Dental caries, the common dental diseases, have affected human widely in modern times. Dental caries is an infectious microbiological disease that results in localized dissolution and damage of the calcified tissues of the teeth. Infection of the dental pulp will take place if dental caries are not treated at proper time.Classification of dental diseases is decided on the basis of certain criteria, such as based on either the caries lesion is within the enamel, dentine or caries lesion touches the pulp. Dental caries is visible in the x-rays. Image processing techniques will help check the x-rays and detect the depth to which the caries lesion is present and then classify the type of caries present in the dental x-rays. Dental treatment is also dependent on this classification. If caries is developed up to the enamel, it is classified as enamel caries and if caries extended up to the dentine then it is classified as dentinal caries. In above two cases, filling is the best solution. And if caries extended up to the pulp then it is known as pulpal caries, RCT (Root Canal Treatment) is the required treatment.

In this paper, we have applied two optimal edge detection techniques, canny and ISEF (Infinite Symmetric Exponential Filter). The paper has been divided in to six parts. Section 2 discusses the problem of dental radiography and possible solution through dental x-ray imaging. In section 3 we propose an approach for detection of depth of dental caries. Section 4 gives the detail explanation of Canny and ISEF edge detection techniques. Section 5 concludes the paper and in section 6 acknowledgments are being provided to specialized dental doctors, without their massive support nothing would have been possible.

II.PROBLEM DEFINITION

The raw data obtained directly from x-ray acquisition device may yield a comparatively poor image quality representation. In case of medical images human involvement and perception is of prime importance. It is a difficult task to interpret fine features in various contrast situations [5]. Dentists interpret the dental x-rays using their knowledge, perception and experience. So there is a chance of error in deciding the right medical treatment. Nowadays digital dental radiographs, in which enhancement is done automatically, are available but the system are very costly. Our algorithm will give alternate solution to this problem. It includes X-ray imaging & its processing for identifying the exact location & depth of damage in affected tooth. As radiographic imaging study in medical practice [6],[7],[8] provides better clue for diagnosis, but it is not merely the final tool; as investigations must be co-related with clinical findings [Courtesy by Dr. Ronak Panchal].

There are many edge detection techniques are available in the literature but Canny and Shen Castan algorithm are the optimal edge detectors[10] .So here we will provide comparative analysis between these two optimal edge detection techniques.

III. PROPOSED APPROACH

Dental treatment is dependent on the caries development up to the enamel, dentine and pulp region. For this diagnosis we suggest a technique as briefed in Table-I. The detail description of the same is explained below it.

Table-1.Suggested Technique

Sr.No.	Steps
1	Acquire digital dental images.
2	Convert image in to gray scale image.
3	Apply morphological and filtering operations for image enhancement.
4	Extraction of caries affected tooth from image.
5	Edge detection using Canny and ISEF (Infinite Symmetric Exponential Filter).
6	Detection and decision based on caries extension inside the tooth as shown in table III.

Dental x-ray images are RGB images, so to reduce the complexity level and time consumption, these images are converted into gray scale images.

Image enhancement is the required task for dental x-ray image as step 3 of table I suggests. In periapical view, as shown in figure 1, we classify three main classes of "objects"; teeth, gum, and air. An area with "bright" gray scales (except for the pulp tissue) consists tooth area while areas with "mid-range" gray scales consists gum area, and "dark" gray scales indicates air. For better segmentation,[11] it is desirable to convert poor quality dental x-rays in to considerable degree of contrast between the dominant gray scales used in capturing the different classes of objects.[7]

Figure 1: Paraipical view of Dental Radiograph
{Courtesy: Dr. Ronak Panchal}

Top-hat and bottom-hat filters are applied on the original image to achieve an enhanced and desired image for further processing [6],[9]. Enhanced image is shown in figure 2.

Figure 2: Enhanced Dental X-ray

Step 4 of table I is caries affected tooth extraction. We extract caries affected tooth from the dental X-rays by image cropping operation, so that caries affected area can be visible more properly as shown in figure 3.

Figure 3: Caries affected Tooth

IV. OPTIMAL EDGE DETECTORS

A. EDGE DETECTION USING CANNY

Canny edge detection algorithm is given in table II.

Table 2.Canny Algorithm

Sr.No.	Steps
1	Read the image I.
2	Convolve a 1D Gaussian mask with I.
3	Create a 1D mask for the first derivative of the Gaussian in the x and y directions.
4	Convolve I with G along the rows to obtain I_x, and down the columns to obtain I_y.
5	Convolve I_x with G_x to have I_x', and I_y with G_y to have I_y'.
6	Find the magnitude of the result at each pixel (x, y). $$M(x,y)=\sqrt{I_x'(x,y)^2+I_y'(x,y)^2}$$

Output obtained after applying canny algorithm is shown in figure 4.

B. *EDGE DETECTION USING ISEF [10]*

Edge detection of caries affected tooth is done by ISEF (Infinite Symmetric Exponential Filter).

Table 3. Isef Algorithm

Sr.No	Steps
1	Apply ISEF Filter in X direction
2	Apply ISEF Filter in Y direction
3	Apply Binary Laplacian Technique
4	Apply Non Maxima Suppression
5	Find the Gradient
6	Apply Hysteresis Thresholding

Shen Castan Infinite Symmetric Exponential Filter is an optimal edge detector. First the whole image will be filtered by the recursive ISEF filter in X and Y direction respectively which can be implemented by using following equations:
Recursion in x direction:

$$y_1[i,j]=\frac{(1-b)}{(1+b)}\,I[i,j]+b\,y_1[i,j-1],\ j=1...N,i=1..M\ldots\ldots(1)$$

$$y_2[i,j]=b\frac{(1-b)}{(1+b)}\,I[i,j]+b\,y_1[i,j+1],\ j=N...1,i=1..M\cdots(2)$$

$$r[i,j]=y_1[i,j]+y_2[i,j+1]\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

Recursion in y direction:

$$y_1[i,j]=\frac{(1-b)}{(1+b)}\,I[i,j]+b\,y_1[i-1,j],i=1...M,\ j=1..N\ldots\ldots(4)$$

$$y_2[i,j]=b\frac{(1-b)}{(1+b)}\,I[i,j]+b\,y_1[i+1,j],i=M...1,\ j=1..N\ldots(5)$$

$$y[i,j]=y_1[i,j]+y_2[i+1,j]\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

b=thinning factor (0<b<1)

Subtract the filtered image from the original image to obtain the Laplacian image. In the filtered image, there will be zero crossing in the second derivative at the location of an edge pixel because the first derivative of the image function should have an extreme at the position corresponding to the edge in image. Non maxima suppression is used for thinning purpose for false zero crossing. The gradient is either a maximum or a minimum at the edge pixel. If the second derivative changes sign from positive to negative, it is known as positive zero crossing and if it changes sign from negative to positive, it is known as negative zero crossing. We will permit positive zero crossing to have positive gradient and negative zero crossing to have negative gradient. We considered all other zero crossing as false zero crossing. Thresholding is applied on gradient image. One cutoff is used in simple thresholding but Shen-Castan suggests for Hysteresis thresholding in which two cut offs are used. Thresholding is applied on the output of an edge detector to decide significant edges. Noise will create spurious response to the single edge that will create a streaking problem. Streaking is defined by breaking up of the edge contour caused by the operator fluctuating above and below the threshold.

Hysteresis thresholding is used to eliminate streaking problem. Individual weak responses usually correspond to noise, but if these points are connected to any of the pixels with strong responses, they are more likely to be actual edge in the image. Such connected pixels are treated as edge pixels if their response is above a low threshold. The ISEF algorithm is given in table II. Output is shown in figure 4.

Figure 4 Output of Canny Algorithm (LT=0.4, HT=0.8)

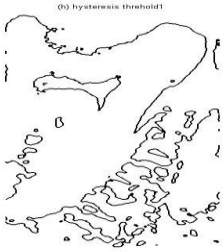
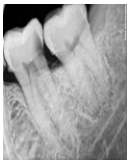
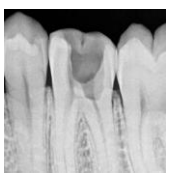


Figure 5 Output of ISEF (LT=30% of maximum intensity HT=70% of maximum intensity)

Results of two optimal edge detectors are shown in table 4.

Table 4. Results of Canny and Isef algorithm

Sr. No.	Original Image	Canny Operated Image	ISEF Operated Image
1			
		MSE-0.7003	MSE-0.3004
		PSNR- 49.6778	PSNR- 53.3534
2			
		MSE- 0.5759	MSE- 0.4226
		PSNR- 50.5275	PSNR- 51.8712
3			
		MSE- 0.7025	MSE- 0.2692
		PSNR- 49.6644	PSNR- 53.4148
4			
		MSE- 0.6235	MSE- 0.3755
		PSNR- 50.1827	PSNR- 52.3848
5			
		MSE- 0.5281	MSE- 0.4704
		PSNR- 50.9034	PSNR- 51.4062

V. RESULTS AND DISCUSSION

Table IV shows comparative results of Canny and ISEF edge detection techniques. We apply these two algorithms on 50 different dental x-ray images and calculate Mean square Error (MSE) and Peak Signal to Noise Ratio (PSNR) for each image.

$$MSE = \frac{1}{M*N}\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}(f(i,j)-g(i,j))^2 \quad \ldots\ldots\ldots(7)$$

$$PSNR = 10*[[\log(255*255)]/MSE] \quad \ldots\ldots\ldots(8)$$

Figure 5 shows the graph of MSE for 50 dental x-ray images.

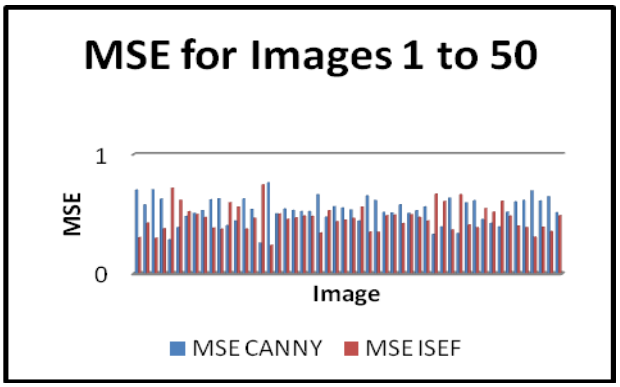


Figure 5 Graph of mean square error for Canny and ISEF

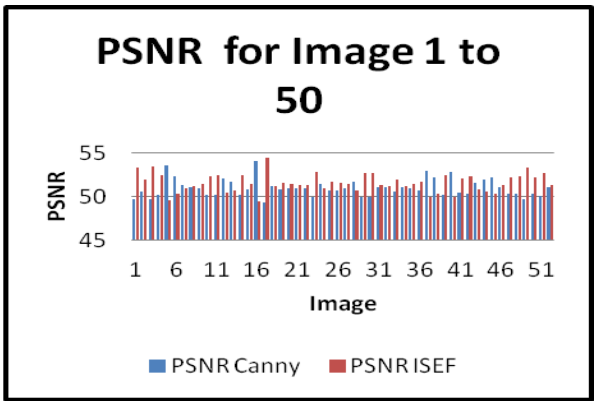


Figure 6 Graph of Peak Signal to Noise Ratio for Canny and ISEF

Figure 6 shows graph of PSNR for 50 dental x-ray images.

VI. CONCLUSION

Shen Castan algorithm gives better results compared to canny as shown from figure 5 and 6. So decision about RCT or filling is done after applying ISEF on dental x-ray images. Resultant images which were also shown to various dentists and the results were not only accurate but well appreciated and recommended for further research.

VII. ACKNOWLEDGMENT

The authors are highly indebted and thankful to Dr. Ronak Panchal (Shakti Orthodontic Care and Multispeciality Dental Clinic, V.V.Nagar, Anand) for their massive supports and suggestions. We are really grateful to Dr. Ronak Panchal for sharing the personal information of various patients for the purpose of our research. The data base so provided is confidential and presented only after the prior permission of doctor and patients.

REFERENCES

[1] G.A.Kulkarni , A.S.Bhide, D.G. Patil, S.S.G.B.C.O.E. & T., Bhusawal, "Two Degree Greyscale Differential Method for Teeth Image Recognition", International Journal of computer Application, 2012

[2] B. Yousefi , H. Hakim, N. Motahir, P. Yousefi1, M. M.Hosseini, "Visibility Enhancement of Digital Dental X-Ray for RCT Application Using Bayesian classifier and Two Times Wavelet Image Fusion", Journal of American Science, pp 7-13, 2012

[3] Ş. Oprea, C. Marinescu , I. Liţă, M. Jurianu, D. A. Vişan, I. B. Cioc, " Image Processing Techniques used for Dental X-Ray Image Analysis" , Electronics Technology, ISSE 2008, pp 125-129

[4] E. H, said, G. Fahmy, D. nassar, H. Amar, "dental X-ray image segmentation" Biometric Technology for Human Identification, Proceedings of the SPIE, Vol. 5404, pp. 409-417, 2004.

[5] S. Kiattisin, A. Leelasantitham, K. Chamnongthai , K. Higuchi, " A Match of X-ray Teeth Films Using Image processing Based on Special Features of Teeth" , SICE Annual Conference 2008, pp 35-39

[6] S. Dighe, R. Shriram, "Pre-processing, Segmentation and Matching of Dental Radiographs used in Dental Biometrics", International Journal of Science and Applied Information Technology, Volume 1, No.2, pp 52-56, May – June 2012

[7] R. B. Tiwari, Prof. A. R. Yardi, "Dental x-ray image enhancement based on human visual system and local image statistics"., International Conference on Image Processing, Computer Vision and Pattern Recognition, 2006, pp 100-108

[8] O. Nomir, M. A. Mottaleb. "A system for human identification from X-ray dental radiographs," Pattern Recognition 38 (2005), pp 1295 – 1305.

[9] S. L. S. Abdullaha, H. A. Hambalia, N. Jamilc, "Segmentation of Natural Images Using an Improved Thresholding-based Technique", International Symposium on Robotics and Intelligent Sensors 2012 (IRIS 2012), pp 938-944

[10]C. K. Modi , K. J. Pithadiya ,J. D.Chauhan, K. R. Jain, " Comparative study of Optimal edge detection algorithms for liquid level inspection in Bottles", International conference on Emerging Trends in Engineering and Technology , pp 447-452, 2009 .

[11] E. H. Said, D. E. M. Nassar, G. Fahmy, H. H. Ammar. "Teeth segmentation in digitized dental X-ray films using mathematical morphology," IEEE Transactions on information forensic and security, vol. 1, Issue. 2, pp. 178-189, June. 2006.

[12] O. Gormeza, H. H.Yilmazb," Image Post Processing in Dental Practice", European Journal of Dentistry ,October 2009 - Vol.3.

[13] S. Shah, A. Abaza, A. Ross, H. Ammar." Automatic Tooth Segmentation Using Active Contour Without Edges", In Biometric Consortium Conference, 2006 Biometrics Symposium: Special Session on Research at the, pp. 1-6. IEEE, 2006.

[14] M. Analoui. "Radiographic image enhancement. Part I: spatial domain techniques", Dento maxillofacial Radiology (2001) 30, pp 1-9.

