# An Approach to Identify Caries in Dental Image

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***Abstract—*** *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. In this paper , we explore image segmentation using ISEF algorithm and active contour model to detect and diagnose the dental caries in case of decayed tooth.*

***Keywords— Lesion, Enamel, RCT, caries, dentine, pulp, ISEF, dental radiograph, dentistry, Canny edge detection algorithm, Snake model.***

## 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 is a major oral health problem in most industrialised countries. The early manifestation of the caries process is a small patch in enamel at the tooth surface. The destruction spreads into the sensitive part of the tooth beneath the enamel called dentine. The weakened enamel then collapses to form a cavity and the tooth is progressively destroyed. 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, ISEF (Infinite Symmetric Exponential Filter) and active contour model. The paper has been divided in to five parts. Section 2 gives the detail explanation of ISEF edge detection technique. In section 3 we discuss about active contour model. Section 4 gives the result of both the techniques and Section 5 gives comparison between the result obtained from ISEF and active contour model .

## II. EDGE DETECTION USING ISEF [10]

There are many edge detection techniques, available in the literature but Shen Castan algorithm is the optimal edge detector[10] . Edge detection of caries affected tooth is done by ISEF (Infinite Symmetric Exponential Filter).

*TABLE.I: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:

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

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

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

Recursion in y direction:

b=thinning factor (0<b<1)

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

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

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

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 I.

## III. CARIES DETECTION USING SNAKE MODEL

The active contours replica (also called snakes) was first introduces by Kass, Witkin, and Terzopoulos (1987) for objective boundary identification. It is defined by an energy function.the energy functional, which is minimized is a weighted combinational of internal & external forces The internal forces serve to impose a peace wise smoothness constrain. External forces are responsible for putting the snake near desired local minimum. By minimizing the energy function, each snake contour point iteratively finds its new situation to move toward object boundaries. The model planned in Kass et al. (1988) performs a global investigate to minimize the energy function. Later, a number of techniques were proposed to decrease the computational complexity of snakes (Williams & Shah, 1992; Lam & Yan, 1994; Mirhosseini & Yan, 1997).

The contour is described in the ($x$, $y$) plane of an image as a parametric curve (s) = (x(s), y(s)) -------------- (7)

Contour is said to take an energy ($E_{snake}$) which is defined as the sum of the three energy terms.

$$E_{snake} = E_{internal} + E_{external} + E_{constraint} \quad \text{---(8)}$$

The energy terms are described cleverly in a way such that the final location of the contour will have a minimum energy ($E_{min}$). Therefore our difficulty of obtaining objects decreases to an energy minimization difficulty.

**Internal Energy ($E_{int}$)**

Internal energy depends on the intrinsic property of the curve and addition of elastic energy and bending energy.

**Elastic Energy ($E_{elastic}$)**

The curve is care for as an elastic rubber band possessing elastic potential energy. It dispirit extending by introducing tension

$$E_{elastic} = \frac{1}{2}\int_s \alpha(s)\,|v_s|^2\, ds \quad \text{---------(9)}$$

Where,

$$v_s = \frac{dv(s)}{ds} \quad \text{----------(10)}$$

Weight α(s) permits us to control elastic energy beside diverse parts of the contour. α used for many applications & responsible for shrinking of the contour.

**Bending Energy ($E_{bending}$)**

The snake is also considered to behave like a thin metal strip giving rise to bending energy. It is defined as sum of squared curvature of the contour.

Total internal energy of the snake can be defined as

$$E_{bending} = \frac{1}{2}\int_s \beta(s)\,|v_{ss}|^2\, ds \quad \text{--------------------------(11)}$$

$$E_{int} = E_{elastic} + E_{bending} = \int_s \frac{1}{2}(\alpha|v_s|^2 + \beta|v_{ss}|^2)ds$$
---------(12)

**External energy of the contour ($E_{ext}$)**
It is obtained from the image. Define a function $E_{image}$ (x,y) so that it obtain on its smaller values at the features of interest, such as boundaries

$$E_{ext} = \int_s E_{image}(v(s))ds$$
----- -------------------------(13)

### IV. RESULTS AND DISCUSSION

#### A. Results of Shen Castan's Algorithm:

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-II. The detail description of the same is explained below it.

*TABLE.II: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 ISEF (Infinite Symmetric Exponential Filter). |
| 6 | Detection and decision based on caries extension inside the tooth |

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]

*Fig.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.

*Fig.2: Enhanced Dental X-ray*

Step 4 of table II 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.

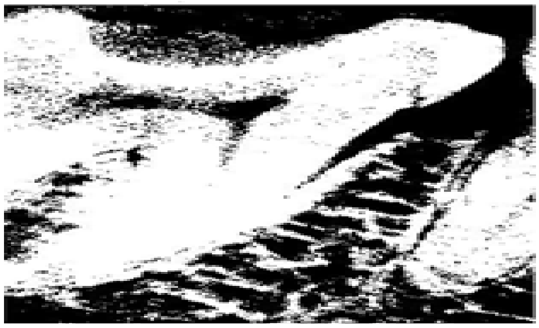


*Fig.3: Caries affected Tooth*

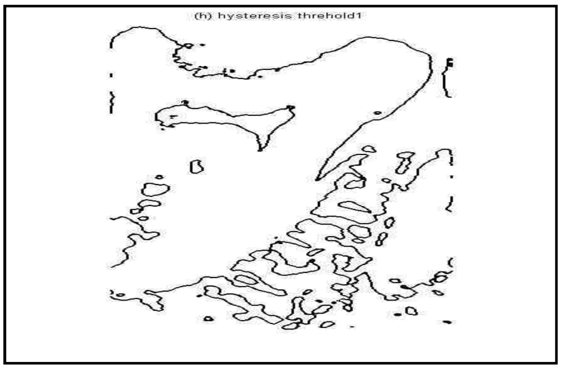



*Fig.4:Output of ISEF (LT=30% of maximum intensity HT=70% of maximum intensity)*

**B. Results of snake Model:**

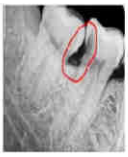
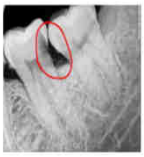
| | | |
|---|---|---|
| <br>**16 points 50 iterations** | <br>**16 points 100 iterations** | <br>**16 points 150 iterations** |
| <br>**22 points 50 iterations** | <br>**22 points 100 iterations** | <br>**22 points 150 iterations** |
| <br>**17 points 50 iterations** | <br>**17 points 100 iterations** | <br>**17 points 150 iterations** |

*Fig.5: Points and iterations in active contour model*

## V. DISCUSSION

We used two approaches for finding caries in caries affected tooth. Using Shen Castan Edge detection method, we find out edge of the caries affected tooth from which we can identify proper treatment like RCT or filling, but We have to select caries affected tooth manually from periapical dental image. Whereas active contour model is a semi automatic approach in which we have to select initial points around the interested area and define iterations. It will find out caries affected area automatically. More iterations define accurate location of caries.

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