Dental Contour Extraction & Matching with Label Contouring Using ISEF Algorithm on DICOM Images for Human Identification

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Abstract- In this paper, the dental contour extraction is done. The Extracted feature is the tooth contours of one person with different time. Then it is compared with radiographs of other persons as they remain more invariant over time compared to some other features of the teeth. ISEF algorithm is used for edge detection. Combining ISEF algorithm and Dental contour Extraction, we get better results in form of matrix to match with another radiographs. Infinite symmetrical exponential filter are used as optimal edge detectors to find better contouring between any teeth contacts and the local deviations on termination boundaries. Also bilinear interpolation method is also used for comparative analysis. Results show that the proposed method achieves a precise measurement of basic dimensions. The proposed approach is invariant with respect to the orientation and it is easy to implement.

Keywords – Contouring, ISEF Edge detector, bilinear interpolation.

I. INTRODUCTION

An edge is defined by a discontinuity in gray level values. Edge detection is one of the most commonly used operations in image analysis. In other words, an edge is the boundary between an object and the background. The shape of edges in images depends on many parameters: The geometrical and optical properties of the object, the illumination conditions, and the noise level in the images. Segmentation of dental image can be done on Region based. a) Gap Valley Detection b) Contour extraction. c) Tooth Isolation.
Shen-Castan's Infinite Symmetric Exponential Filter-ISEF Algorithm: Single dimension filter function, it is real continuous function:

$$f(x) = \frac{p}{2} e^{-p|x|}$$

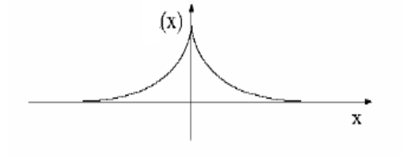


Figure1. Graph of exponential filter

$$f[i,j]=\frac{(1-b)b^{|x|+|y|}}{(1+b)}$$

Where b is the Thinning Factor and its values lies in between 0 and 1 i.e $0<b<1$

There are number of templets available for edge detection, but Shen-Castan's Infinite symmetric exponential filter based edge detector is an optimal edge detector which gives optimal filtered image. First the whole image will be filtered by the recursive ISEF filter in X direction and in Y direction, which can be implement by using equations as written below.

Recursion in the X direction:

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

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

$$r[i,j]=y_1[i,j]+y_2[i,j+1] \tag{3}$$

Recursion in y direction:

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

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

$$y[i,j]=y_1[i,j]+y_2[i+1,j] \tag{6}$$

b=Thinning Factor ($0<b<1$)

After Substracting the filtered imagefrom original image, we can approximate the Laplacian image. At the location of an edge pixel there will be zero crossing in the second derivative of the filtered image. The first derivative of the image function should have an extreme at the position corresponding to the edge in image and so the second derivative should be zero at the same position. And for thinning purpose apply non maxima suppression as it is used in canny for false zero crossing. The gradient at the edge pixel is either a maximum or a minimum. If the sign is changed from positive to negative when second derivative is taken then it is called positive zero crossing and if sign changes from negative to positive it is called negative zero crossing. We will allow positive zero crossing to have positive gradient and negative zero crossing to have negative gradient, all other zero crossing are assumed to be false and are not considered as edge. Now gradient applied image has been thinned, and ready for the thresholding. The simple thresholding can have only one cut off but Shen-Castan suggests to use Hysteresis thresholding.

Spurious response to the single edge caused by noise usually creates a streaking problem that is very common in edge detection. The output of an edge detector is usually thresholded, to decide which edges are significant and streaking means the breaking up of the edge contour caused by the operator fluctuating above and below the threshold. Streaking can be eliminated by thresholding with Hysteresis. 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 there response is above a low threshold. Finally thinning is applied to make edge of single pixel. Block diagram of ISEF algorithm is shown in figure-2. Figure-3 shows the recursive filter in X and figure-4 shows recursive filter in Y direction. The ISEF algorithm is given in Table III.

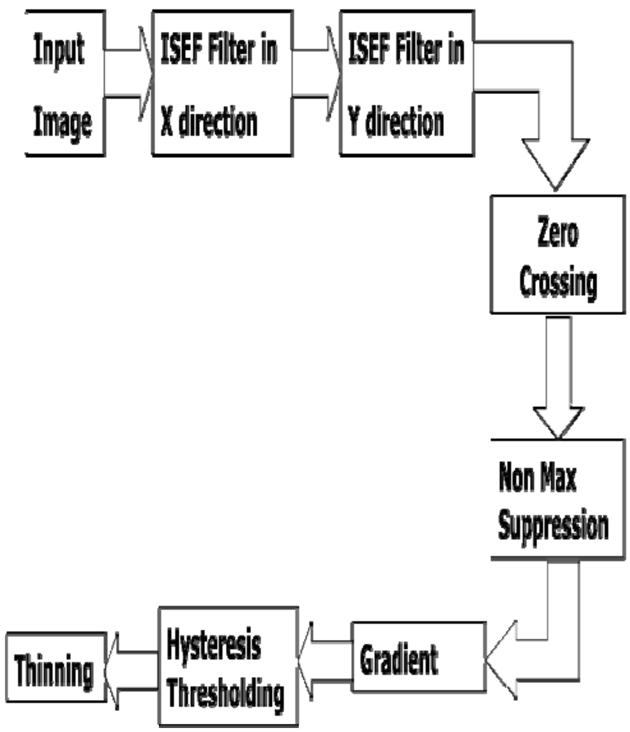


Figure 2. Block diagram of ISEF algorithm

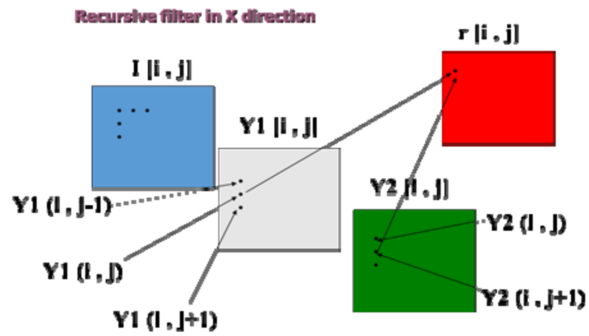


Figure 3. Diagram of Recursive filter in X direction

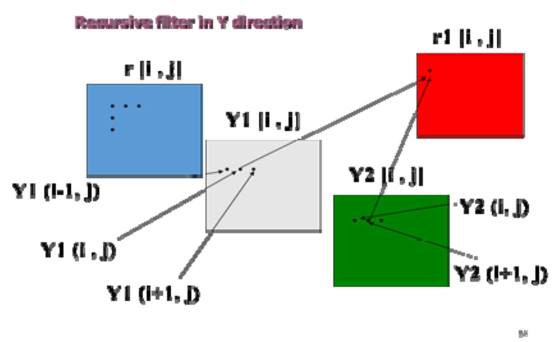


Figure 4. Diagram of Recursive filter in Y direction

II. Bilinear Interpolation

Contour plots of any matrix are level curves of the matrix drawn by treating the values in the matrix as heights above a plane. For image contouring, matrix is image data. Contour in image matrix data is just like bilinear interpolation which is described below.

Points $Q_{11} = (x_1, y_1)$, $Q_{12} = (x_1, y_2)$, $Q_{21} = (x_2, y_1)$, and $Q_{22} = (x_2, y_2)$.We first do linear interpolation in the *x*-direction. We proceed by interpolating in the *y*-direction to obtain the desired estimate: Note that we will arrive at the same result if the interpolation is done first along the *y*-direction and then along the *x*-direction.

$$f(x, y_1) \approx \frac{x_2 - x}{x_2 - x_1} f(Q_{11}) + \frac{x - x_1}{x_2 - x_1} f(Q_{21})$$

$$f(x, y_2) \approx \frac{x_2 - x}{x_2 - x_1} f(Q_{12}) + \frac{x - x_1}{x_2 - x_1} f(Q_{22}) \quad (7)$$

$$f(x,y) \approx \frac{y_2 - y}{y_2 - y_1} f(x, y_1) + \frac{y - y_1}{y_2 - y_1} f(x, y_2)$$

$$\approx \frac{y_2 - y}{y_2 - y_1} \left(\frac{x_2 - x}{x_2 - x_1} f(Q_{11}) + \frac{x - x_1}{x_2 - x_1} f(Q_{21}) \right) + \frac{y - y_1}{y_2 - y_1} \left(\frac{x_2 - x}{x_2 - x_1} f(Q_{12}) + \frac{x - x_1}{x_2 - x_1} f(Q_{22}) \right)$$

$$= \frac{1}{(x_2 - x_1)(y_2 - y_1)} \left(f(Q_{11})(x_2 - x)(y_2 - y) + f(Q_{21})(x - x_1)(y_2 - y) + f(Q_{12})(x_2 - x)(y - y_1) + f(Q_{22})(x - x_1)(y - y_1) \right) \quad (8)$$

Figure-5 shows contour plot of any matrix. Figure-6 is taken from applying contour label function and we can see how contours patterns) are build up, these patterns are matched with other contour (patterns) of different images.

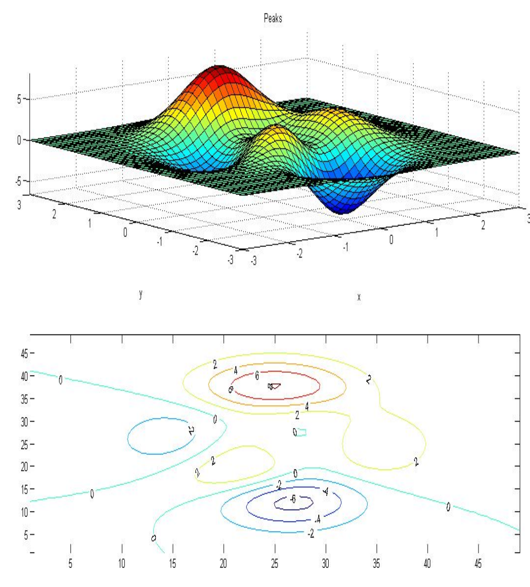


Figure 5. Contour plot

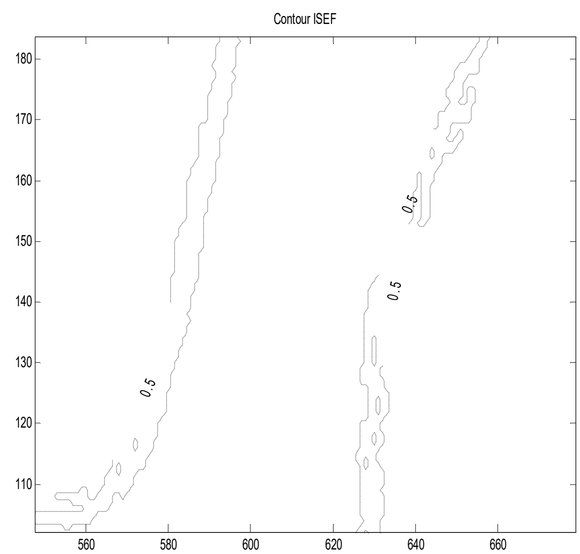
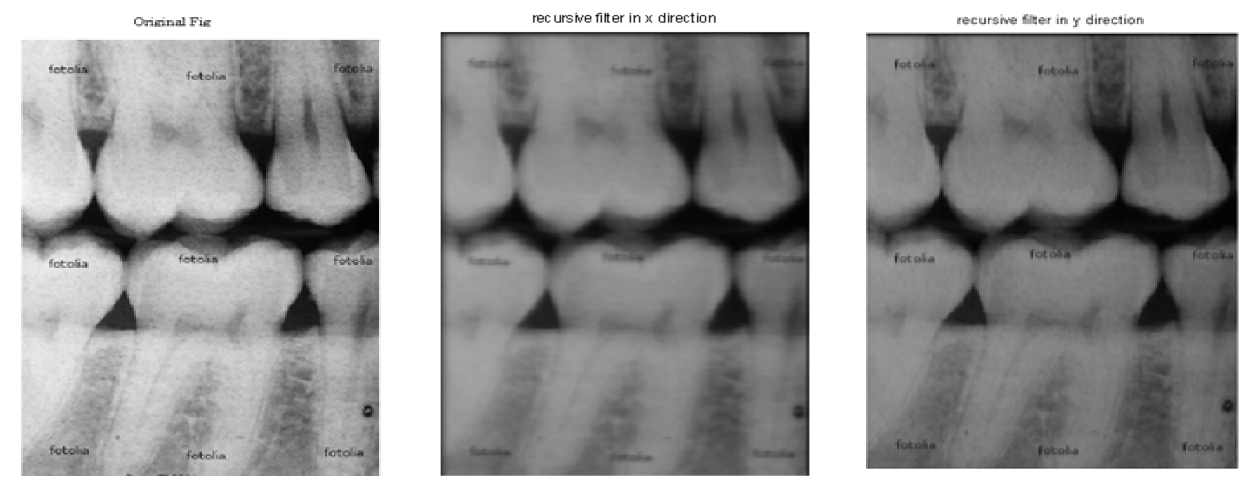


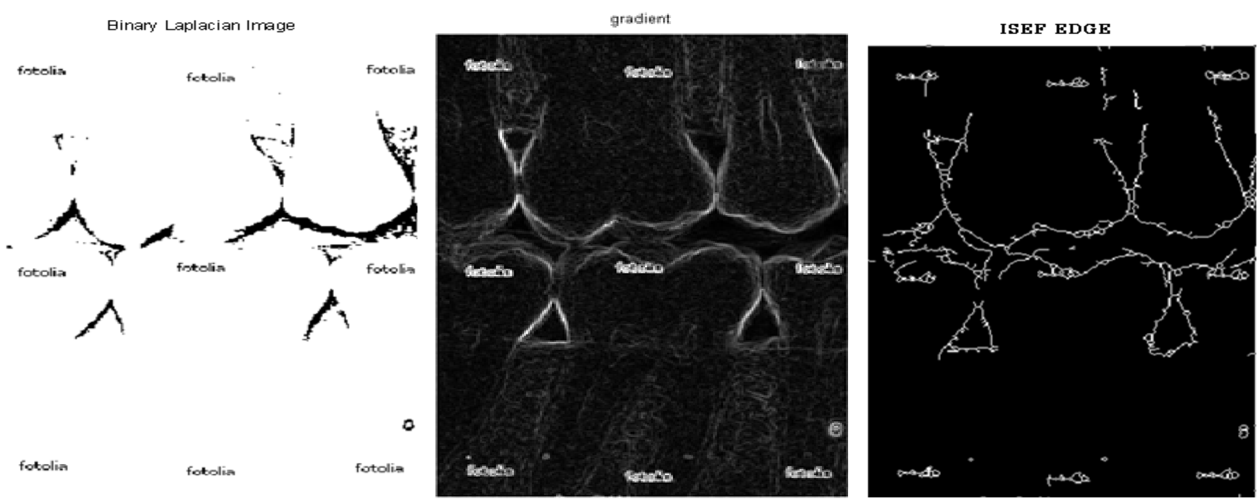
Figure 6. Contour label function applied on image

III. RESULT



(a) (b) (c)

Figure 7. (a) Original Dental, (b) Recursive filter in x, (c) Recursive filter in y



(a) (b) (c)

Figure 8. (a) Binary Laplacian (b) Gradient, (c) ISEF Edge

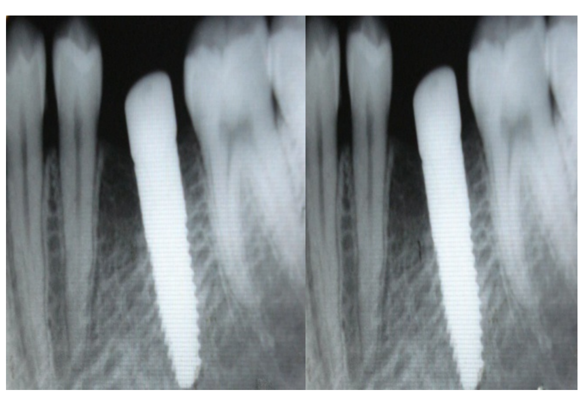


Figure 9. P34 & P35 Ref. Images one person

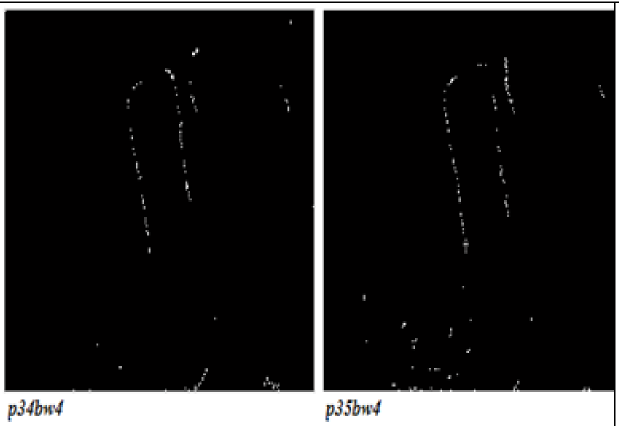


Figure 10. P34 & P35 ISEF operated Images

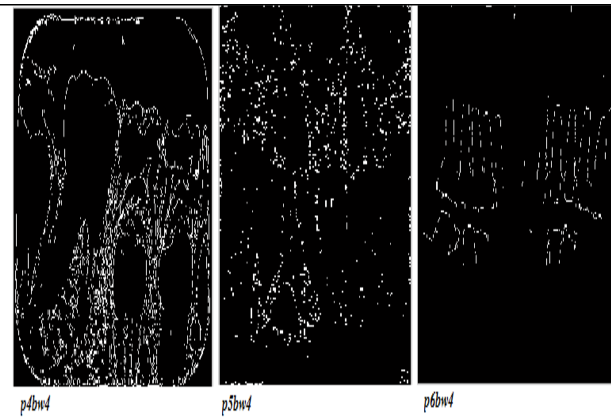


Figure 11. P4,P5,P6 Other person's ISEF operated

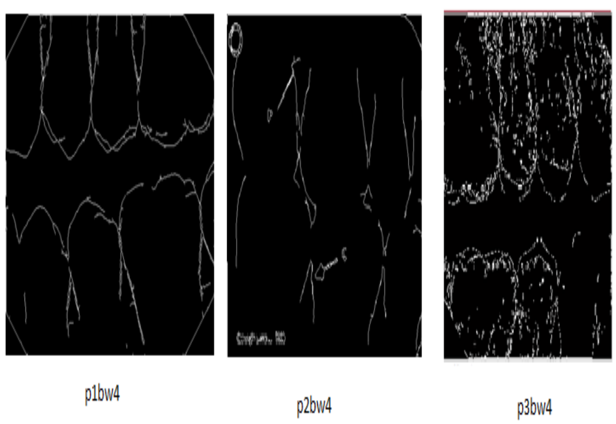


Figure 12. P1,P2,P3 Other person's ISEF operated

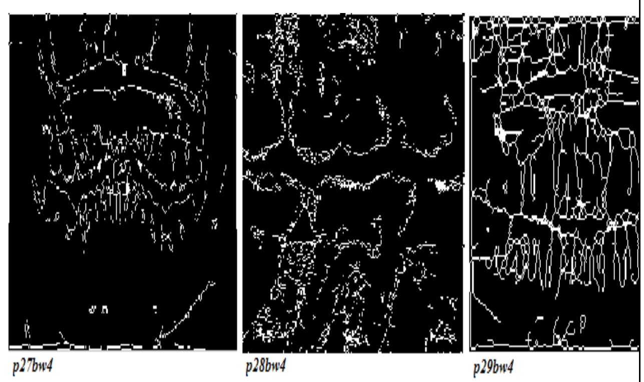


Figure 13 P27,P28,P29 Other person's ISEF operated

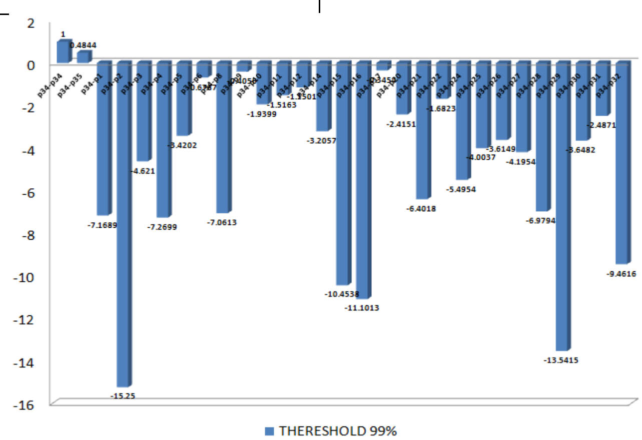


Figure 14. Graphical representation of P34 with Other person's data

Table-1 shows others matching data with image P34.

Table-1 Others matching data with image P34

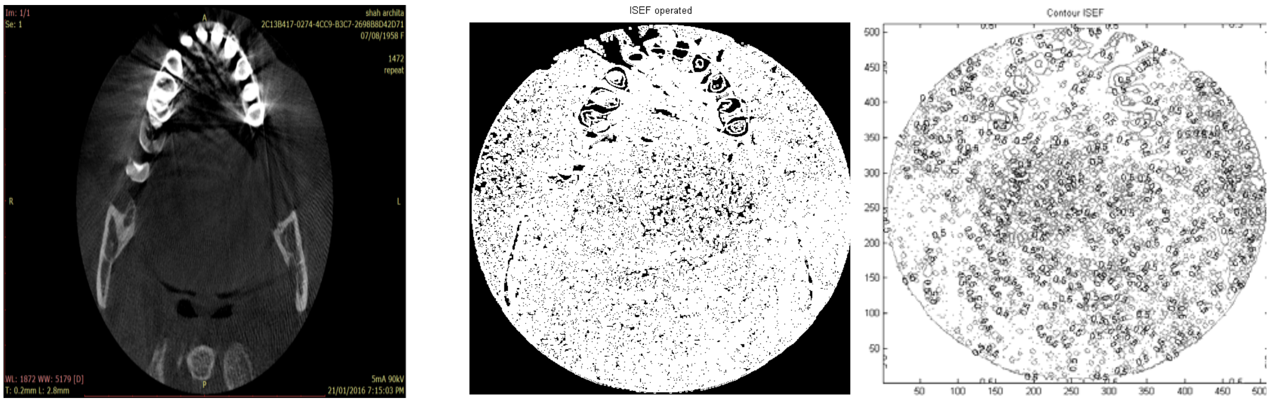
Fig.	Maximum pixel	Match	Mismatch	Percen%	TH 99% (Per.- Th)
p34-p34	687354	687354	0	100	**1**
p34-p35	656502	653117	3385	99.4844	**0.4844**
p34-p1	161000	147848	13152	91.8311	**-7.1689**
p34-p2	200000	167517	32483	83.75	**-15.25**
p34-p3	200000	188758	11242	94.379	**-4.621**
p34-p4	187500	171994	15506	91.7301	**-7.2699**
p34-p5	393216	375835	17381	95.5798	**-3.4202**
p34-p6	307200	302043	5157	98.3213	**-0.6787**
p34-p8	187500	172385	15115	91.9387	**-7.0613**
p34-p9	307200	302882	4318	98.5944	**-0.4056**
p34-p10	178000	172767	5233	97.0601	**-1.9399**
p34-p11	178000	173521	4479	97.4837	**-1.5163**
p34-p12	178000	173532	4468	97.8499	**-1.1501**
p34-p14	81200	77785	3415	95.7943	**-3.2057**
p34-p15	204282	180884	23398	88.5462	**-10.4538**
p34-p16	124416	109360	15056	87.8987	**-11.1013**
p34-p17	362414	357538	4876	98.6546	**-0.3454**
p34-p20	132908	128369	4539	96.5849	**-2.4151**
p34-p21	75900	70282	5618	92.5982	**-6.4018**
p34-p22	165120	160691	4429	97.3177	**-1.6823**
p34-p24	480000	448822	31178	93.5046	**-5.4954**
p34-p25	93450	88774	4676	94.9963	**-4.0037**
p34-p26	105679	100802	4877	95.3851	**-3.6149**
p34-p27	131520	124687	6833	94.8046	**-4.1954**
p34-p28	106800	98278	8522	92.0206	**-6.9794**
p34-p29	36186	30924	5262	85.4585	**-13.5415**
p34-p30	36100	34422	1678	95.3518	**-3.6482**
p34-p31	153450	148099	5351	96.5129	**-2.4871**
p34-p32	3939840	3527668	412172	89.5384	**-9.4616**

Table-2 contour per matching (%) for different images.

FIGURE	CONTOUR PER MATCHING (%)
Fig p34 -P34	100
Fig P34-P35	33.54
P1	0
P2	0
P3	0
P4	0
P5	0
P6	0
P9	0
P13	0
P14	0
P19	0
P20	0
P21	0
P25	0
P26	0
P27	0
P28	0
P29	0

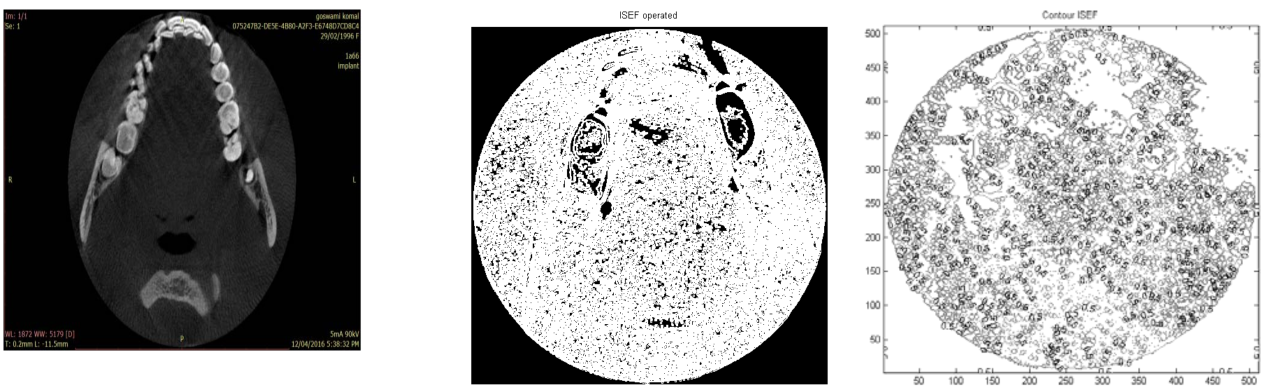
DICOM Images

Some DICOM images are taken for more analysis.



(a) (b) (c)

Figure 15. (a) Dicom image of archita (b) ISEF (c) Contour Image



(a) (b) (c)

Figure 16. (a) d1_am image (b) ISEF image (c) contour image

Table-3 Contour per matching (%) for different DICOM images.

FIGURE	**CONTOUR PER MATCHING(%)**
d9_am – d9_am	100
d9_am – d1_am	76-86
d9_am - d1_archita	69-72
d9_am - d1_ck	6-12
d9_am - d1_Pa	59-63
d9_am - d1_mb	25-43

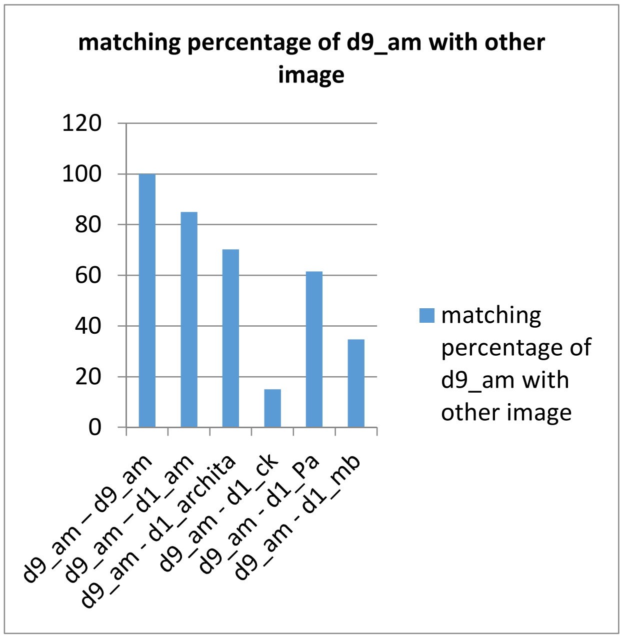


Figure 17. Graphical representation of comparison of d9_am DICOM image with Other person's DICOM image.

IV. CONCLUSION

In this Paper we have applied ISEF edge detection algorithm to Reference images P34 & P35. Here P34 is one person image which is having radiographs without screw is implanted & P35 is radiographs of same person with screw is implanted after three years gape. Now we have compared P34 image with P35 & with other general images from different sources. So after comparison with optimal threshold more edge data is matched with P35 than other image's edge data is less matched with P34. From Table-1 it can be seen that for different images threshold is under zero. Here we have taken Whole image means with background, in future if we select only edge is to be match with all other images might be get better results. Figure-14 and Figure-15 shows the ISEF and contour of DICOM images of different persons. Here d1_am is reference DICOM image with that other DICOM images are compared. Table-3 shows matching percentage of d1_am with other other images. So after all optimization we proved that by this algorithm we can identify person with dental radiographs, & it can be used AM, PM images. It can be also used in Police & defense dept. to identify the person.Also from Table-2 we can say after applying bilinear interpolation, we can see the results if we have different person's image, matching percentage is zero as here we have applied our novel tool.

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