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Dental Image Segmentation Using Fast Marching Method for 2D to 3D Registration

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ABSTRACT

In dentistry radiographic examination plays an important role to analyse the structure of the dent. Analysis can be done in two ways .First one is manual method which involves the assumption of the experienced professionals. It may lead to failure if the assumption is not correct .On the other hand automatic methods which use image processing techniques to visualize the needed information. Medical image segmentation plays a major role in medical image processing. Several image segmentation techniques have been proposed to extract the region of interest. In this paper the region of interest is extracted by using level set based fast marching methods. Compared to other techniques fast marching method gives good efficient result by its adaptive ability. This technique also has the added advantages of automatic starting point selection, user influenced region expansion and statistical region combination. The segmented image using Fast marching method can give clear analysing structure to process it.

Keywords: Dental Implantation, Panoramic radiography, Segmentation, Fast Marching Method, Boundary value

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INTRODUCTION

Human teeth are hard calcified structures which use to swallow the food items. Dental cavities make damages in the teeth structures. Panoramic X-Ray images are very popular as a first tool for diagnosis in odontological protocols. Two different techniques are followed by dentist to analyse it. First technique is manual analysing and the second one is automatic method [1]. In the manual technique human experience may causes deviation in the real result. To avoid these problem automatic techniques should be identified. Automatic methods use image processing techniques which involve segmentation technique. Segmentation plays a major role in medical field. Segmentation techniques used to extract the region of interest from the image background. This object location is usually calculated by edge detection, an intensity measure or a target recognition algorithm. However most of these techniques suffer from different types of noise due low resolution or poor lighting, which results in un-successful segmentation [2].

Teeth segmentation is one of the important components in building of the Automated Dental Identification system [ADIS] [3].Many segmentation methods were introduced in the medical field. In dental implantation segmentation is used to extract the teeth structure for analysing its properties. Many tooth segmentation methods have been proposed by considering its intensity measure, edge detection or target recognition algorithm.

Edge detection is the method of segmentation to detect the sharpness and intensity value of the image.Sobel and Robert are the basic edge detection used in many medical image processing. Robert detection uses the average value of the edge .It is not suitable for the dental image processing [1].

Teeth contours are also identified using graph based algorithm. It is suggested that contour teeth separation model can be used as biometric identifier. But the drawback of the graphic method is time consumption [5].Markov random field based algorithm is used to segment the magnetic resonance (MR) images [6] [5]. Fuzzy C- means algorithm is proposed to segment the images for converting two dimensional MR images into three dimensional MR images [7] [8]. In [9], novel radiograph image segmentation approach is presented using morphological filtering. In [10], a model-based computer vision system is presented for automatic segmentation of bones from digital hand radiographs. In [5] an automated morphological filtering wavelet based approach is introduced for tooth segmentation in X-ray images.

In [11] the clustering methods have been discussed for medical image segmentation in particularly for MR Images of brain and are successful in combining fuzzy c means and k-means to get novel fuzzy-k means algorithm. Few limitations of the obtained algorithm have been also stated.

Hybrid technique for medical image segmentation is suggested in [12] and mainly works on fuzzy-c means and otsu‟s method after applying on vector median filter, for segmentation and has tried to prove the robustness of their method few kinds of noise have been added to image and have obtained satisfactory results. A new technique for general purpose interactive segmentation of N-dimensional images using graph-cut method has been proposed by Yuri and Jolly [13]. In their proposed method the user marks certain pixels as “object” or “background” to provide hard constraints for segmentation. They claim that their method gives best balance of boundary and region properties compared to other segmentation methods and also that it provides optimal solution for N-dimensional segmentation.

The list of related works done in the field of image segmentation is very large and can hardly be mentioned. There are various survey and reviews [14] [15] done on these methods periodically. The following sections gives brief principle followed to segment images. Intensity based method and discontinuity based methods were clearly discussed in [4].

The threshold based segmentation techniques are inexpensive, computationally fast and can be used in real time applications with aid of specialized hardware. There are several methods employed for detection of threshold value to name a few mean method, p-tile- thresholding, bimodal histogram, optimal thresholding, multispectral thresholding, edge maximization method [17].Edge detection basically involves the following steps: smoothing the image, edge detection and edge localization. [18]. Algorithms and methods discussed above suffer on poor quality images. So it is difficult to analyse .it may lead to severe problem. As well as the techniques discussed above need human interaction, hence they are not fully automated. These drawbacks can be eliminated by using fast marching method which is discussed here.

FAST MARCHING METHODS

The fast marching method is the modified model of the level set method. Level set methods require more steps to evaluate and re-evaluate the position in three dimensional spaces. It is computationally expensive. This is the main drawback of Level set method. These drawbacks are eliminated by modifying level set method. It constraints by monotonically expand the front, and it produces no negative impact on other techniques. Approximation techniques are used to exchange this constraint with a single pass over the data space. Supposing that F(x, y) describes the monotonically expanding movement of the front at each point it will cross, we can now also define a function T(x, y) that defines the time at which the front arrives at a given point (x, y). It is then evident that or the gradient of

$$|rT|F = 1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots .. (1)$$

The arrival time is inversely proportional to the speed of the front [13]. The algorithm selects the lowest arrival point by searching the narrow band pixel by pixel. These operations are continued to get a good approximation of the growth in the entire image. These approximation techniques introduces margin of error. But the error introduced by approximation is very minimum. It doesn't make any deviation in the result. So it is worth to consider the results are accurate. However a mechanism should be needed to prevent the expanding front from swallowing the entire image by using stopping criteria. Implementation of this method is very difficult, that is the reason of designing a force function to minimize overshoot effect [13]. Instead of using monotonically advance force function, complex function can be selected to draw the front back toward a boundary. Complex function introduces extra computational effort it requires more time as well as difficult for complex structures. The next section is explained about the method of solving the stopping criteria problem without using the mechanism which discussed above. The proposed method introduces a new function into the force factors as long as it is increased monotonically. The new force function is defined by the formula

$$F(x) = e^{-r|I(x)|} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where x is some point in the image, |I(x)| is the magnitude of the image gradient at that point x, and r is a positive parameter to adjust the strength of the function. It speeds up the front in uniform areas by simply slowing the front down function. If the edge-preserving smoothing filter uses before calculating I then significant amount of noise can be reduced.

EXPERIMENTAL RESULTS

A dental panoramic radiography image with the size of 2858 x 1348 is shown in figure 1.Input image size is reduced by applying it to resize function. Resized image is converted into gray image to process it effectively. Converted Image is reduced considerably with size of 731 x 351 as shown in figure 1. Initial mask is created which evolves from outer portion of the image towards centre to identify the region of interest. Intensity variation and cut-off for differentiating the intensity variation is initialized. Threshold level is set as 0.20 for detecting the variation in its intensity. After initialization of all the fundamental parameter, fast marching method is executed. Fast marching method involves many stages of operation. It gives the segmented image as the result from the weights described in an array and seed locations specified by mask. Ideally gray difference weights should have high values in the region which is to be segmented as the foreground object and low values elsewhere. Here the condition is gray difference weight should have the positive values. Mask is the logical image of the same size as gray difference weight. Locations where Mask is true are seed locations. Segmented output is a logical array of the same size as gray difference weight matrix. Threshold function is a non-negative scalar in the range [0 1] which specifies level at which the output of the Fast Marching Method is threshold to obtain the output binary image. Low values of Threshold typically result in large foreground regions in segmented image, and high values of Threshold produce small foreground regions. Fast marching method gives the segmented result which is shown in figure 2.From the result, it is concluded that data size is reduced considerably. This segmented image is suitable for registration of image data because it requires minimum storage space. The matrix size is also reduced considerably. So that it can process effectively. Another important conclusion is derived that the intensity variation depict clearly. Dentist can do the clear analysis with the help of segmented result. Thus the human error can be reduced in the analysis of dent. In 2D to 3D conversion of dental image, FMM segmentation can be used in the first stage for the proper registration.

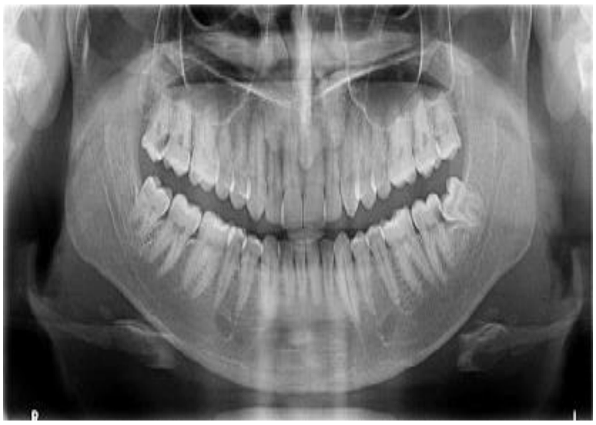

Figure 1 Input Image

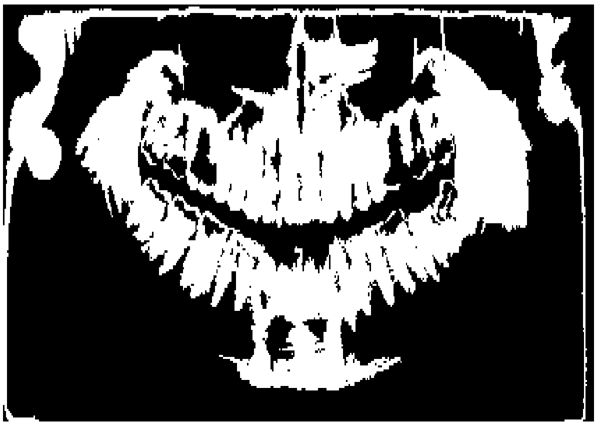

Figure 2 FMM segmented Output

CONCLUSION

The fast marching method proposed here provides an efficient segmented result. This results help to visualize the intensity variation. From the observed intensity variation dentist can predict the density of the dent. It makes them to take an effective decision in the process of dental implantation. These segmented results can also be used in the registration of 2d to 3d images. Registration involves the storage of image matrix which should be the minimized matrix in order to process it's effectively. The technique proposed here is the automatic method which initialized and identifies the region of interest within the time taken by other methods.

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