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An Efficient Segmentation Algorithm for Panoramic Dental Images

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Abstract

Imaging techniques play an important role in improving the early diagnosis and detection process that helps specialists, and dentists to make an accurate diagnosis. One of the most useful medical images used by dentists is a panoramic radiographic image, which is used for diagnostic diseases that is requiring a broad coverage of the jaws. Segmentation is a fundamental step in any image application. The accuracy of segmentation process determines the success or failure of the final analysis process. The wisdom tooth is the third molar, because the lack of room to allow the wisdom teeth to erupt, it commonly affects other teeth as they developed and become partially erupted or impacted. In order to diagnose the problems with the wisdom teeth automatically and prepare the image for final analysis, a pre-processing step is proposed to prepare the panoramic image for segmentation, and then a segmentation algorithm is implemented and followed by post-processing stage.

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Keywords: dental panorama, wisdom teeth, segmentation, image procesing.

1. Introduction

With the continuous evolution of medical radiological imaging in the past decades, medical image processing evaluated and became fundamental tool for researchers in clinical fields, including Dentistry. Segmentation used in dental area to identify part of jaws or teeth or parts of them, it can also be used to identify decay tumors and abscess in the jaws bone, but it faces many difficulties and problems, these problems are found in any medical field in general

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but it increase in dental area [1]. These problems include noises, low contrast and uneven exposure [1]. Segmentation process faces extra problems, such as similarity of body tissues, permanent artifacts such as tooth fillings and dental implants and temporary artifacts like orthodontic braces, impacted teeth, teeth crowding, space between teeth and missing tooth, which make it more challenging process [1]. A successful segmentation method is not always suitable to work with different types of images and problem areas, due to differences in the nature of images and the variation of problems in each image [1].

Dental Radiography is useful tool to diagnose invisible problems of teeth and mouth, such as hidden caries, pulpitis, and tooth abscess. Panoramic X-ray also known as orthopantomogram is a panoramic scanning of dental X-ray of two-dimensional view of the jaws shows the entire teeth in both upper and lower jaws with tissue and supporting structure around it from ear to ear in a single radiography [2] it used to diagnosis different oral problems such as impacted teeth. Wisdom tooth is an extra teeth and each human can have from zero to four wisdom teeth in rare cases can have more than four [3]. Due to the lack of room that allows the wisdom teeth to erupt, it commonly affect other teeth as they develop and become partially erupted or impacted. The non-fully emergence of the wisdom teeth increase the risk of several problems such as accumulation and packing of food debris and bacteria which can lead to dental caries, periodontal diseases, inflammation or infection or damage to wisdom tooth and the adjacent teeth. It also can cause inflammation of operculum covering partially erupted tooth. These complications can affect the other teeth and lead to discomfort and extreme pain, and usually when this occur, wisdom teeth are removed surgically and in rare cases the nerve in lower jaw could get damaged during the removing process [4].

Many researches has carried out in dental radiography processing and segmentation, a novel approach to teeth segmentation was presented by Al-Sherif, N. et al. [5] based on adapting the seam carving technique. The x-ray Image preprocessed by using adaptive thresholding before the segmentation algorithm can be applied. The teeth images were preprocessed by a two-step thresholding technique, first with an iterative thresholding followed by an adaptive thresholding to binarize the teeth images. Then, to separate each individual tooth seam carving technique on the binary images was adapt using both horizontal and vertical seams, to separate each individual tooth. Patanachai, N. et al. [6] proposed segmentation technique for dental panoramic images using wavelet transformation, the image was enhanced using morphological image processing. The result of segmentation is a teeth feature marking each pixel. Such as, edges detection from image segmented.

Lira, P. et al. [7] proposed a segmentation approach for dental X-rays based on a supervised learning technique for texture recognition. First, feature extraction is performed by computing moments, and statistical features. The obtained data are the input to a Bayesian classifier that, after training, can distinguish two classes of pixels: active, inside the target texture or inactive, outside the teeth).

Barboza, E. et al. [8] proposed semiautomatic segmentation method for panoramic images to be used in Semi-automatic dental recognition. The proposed algorithm is based on Differential Image Foresting Transform (DIFT), a graph-based segmentation algorithm used to extract the contour of teeth. To enhance the teeth contours on pre-processed stage, the semiautomatic tooth segmentation was done using Sobel operator. The segmented images were post-processed by using two Mathematics Morphology operators, opening and closing, to achieve smoother contours. The segmentation algorithm provides accurate results and requires little human intervention during the segmentation process.

2. The Proposed Segmentation Method

The proposed segmentation method aims to extract wisdom teeth to be used later in classification and extract useful information such as teeth shape and degree of deviation. This information can be used to classify wisdom teeth as impacted, partially erupted, or completely erupted. Segmentation of the wisdom teeth is done in three stages, pre-processing, ROI extracting or defining and finally post-processing, the stages is shown in fig. 1 with the expected results from each stage, this method was implemented and tested using MATLAB on 97 panoramic x-ray images, each image contains one wisdom tooth

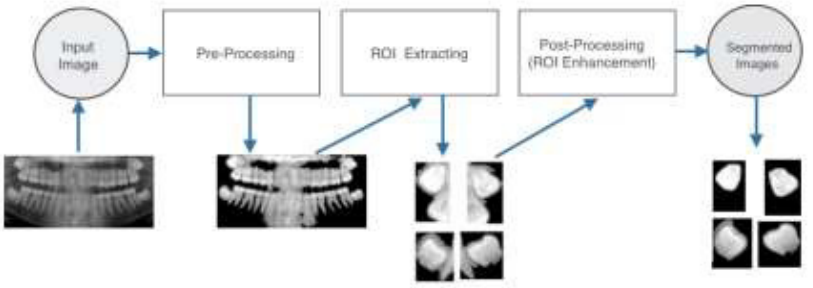


Fig. (1): The main stages of the segmentation method with the expected results from each stage

2.1. Pre-Processing

The objective of image pre-processing can be to improve the original image and make it more suitable for human viewers or to enhance their performance for later analysis and processing, it also can used to aid algorithm performance in some application such as image analysing, computer vision and object detection [9]. In this study, the processing stage is a necessary a pre-processing step that aims to improve the effectiveness of the dental images and prepare it for the segmentation algorithm by removing unwanted region from the image, and clarifying jaws and teeth area.

The Steps of pre-processing stage are:

- Contrast enhancement: manipulating contrast of image help in distinguish teeth region from other tissues and increase structure visibility that gives better result to threshold process. Choosing the right contrast enhanced method depends on the nature of the image. After testing different contrast enhancement methods on the data set images in our proposed study, contrast enhancement using intensity transformations technique was used. The contrast of image was increased by mapping the intensity values in grey scale input image I, to the new values in the output image J, so 1% of data on lower and higher intensities values of I is saturated.
- Threshold using Otsu's method: global Otsu's threshold was used to remove as much as possible of unwanted areas around the jaws and wisdom teeth.

- Morphological Dilation: Dilation was applied using 7x7 ones matrix, to connect objects of teeth and jaws, and to close holes between them and get more smooth borders, the size of the ones matrix was determined depending on the size of the panoramic images and after testing different sizes of matrices.
- Connected Component Labeling: connected component labelling (CCL) was applied to find all objects in the image and distinguish unwanted regions, the object with the largest size represent jaws and teeth.
- Removing unwanted objects: after finding objects in the images and their sizes, all small objects were removed.
- Image multiplication: The resulted image from the last step was multiplied with the enhanced image resulted from contrast enhancement step

The steps of the pre-processing stage are illustrated in fig.2

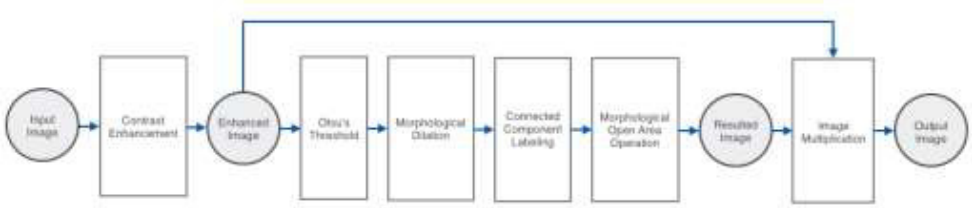


Fig (2): Pre-processing.

The original image panoramic image is shown in fig. 3, and the result of the pre-process is shown in fig. 4

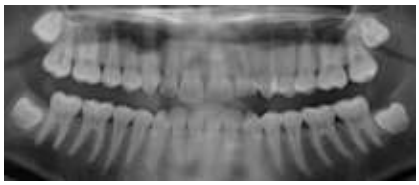


Fig (3): Original Image.

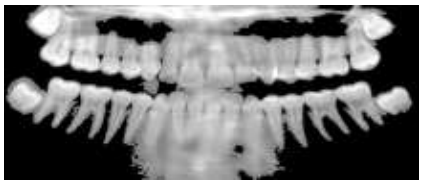


Fig (4): Pre-processing result.

2.2. Extracting ROI

The region of interest (ROI) was extracted automatically based on the common characteristics between the panoramic images and nature of jaws and wisdom teeth location. The size of the extracted region was defined based on the average width of the wisdom teeth in the panoramic images, and it was different for each jaws; because wisdom teeth in upper jaws tends to be smaller than the wisdom teeth in lower, the height of the extracted region was dynamic, The extracting stage consist of the following steps:

1. The panoramic images were divided dynamically into two horizontal parts. The upper part is one third of the image height and hold wisdom teeth in upper jaw. The Second lower part is two thirds of the image height and hold wisdom teeth in lower jaw.
2. The zero pixels in each ends of the images parts were cropped out.
3. Two different masks were applied on each jaws, on the upper jaw the width of the mask was set to 82 pixels based on pre-calculation, and for the lower jaw the width was set to 89 and the length of the mask was dynamic. Assuming that the panoramic image has four wisdom teeth, four masks were applied on each ends of the image.
4. Step 2 was repeated to crop out unwanted zero pixels if found around the teeth.

The steps of extraction the ROI can be written as following:

- Read image height (h)
- Divide image based on the height (h) into three equal parts, h1,h2,h3

  Upper_part=h1

  Lower_part=h2+h3
- Find zero pixels on Upper_part and Lower_part and crop this zero pixels out.
- Apply dynamic length mask on each end of Upper_part and Lower_part where:

  U1= 82 pixels from the left side from upper_part

  U2= 82 pixels from the right side from upper_part

  L1= 82 pixels from the left side from lower_part

  L2= 89 pixels from the right side from lower_part
- Find zero pixels in U1,U2,L1,L2 and crop the this zero pixels out.

The result is shown in fig. 5.

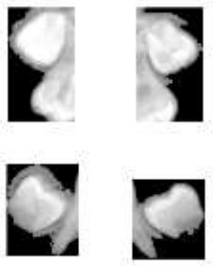


Fig.(5): The extracted ROI.

2.3. Post-Processing

To remove the remind parts from the adjacent teeth in the ROI and get the tooth shape, post-processing is performed. This stage is similar to the pre-processing with, the steps is as the following:

- Histogram Equalization: to separate adjacent tissue from the wisdom teeth, (histogram equalization) HE was applied. This technique adjust image intensities to enhance contrast by transforming the values in an intensity image, it is a non-linear alters and transformation of the data. It takes the histogram of the image (bins of intensities)

and redistributes the pixels so that there are roughly an equal number of pixels in each of the bins. While for example, contrast enhancement using intensity transformations technique, performs a linear scaling of the original data, thus there no lose for information other than the original pixel intensities and it scale the intensity values in the original image to cover the entire dynamic range ([0 1]) [10].

- Global Otsu's threshold: threshold was applied to segment teeth from other tissue.
- Morphologically open image operation: to separate any tissue that still attached to wisdom tooth, a disk shape-structuring element was applied, and the morphological open image operation is erosion followed by dilation, using the same structuring element for both operations.
- Connected component labeling: was applied to distinct wisdom tooth from other regions
- Removing unwanted region: since the biggest region represent wisdom tooth, morphological 'area opening' operation was used to remove other small regions that have number of pixel less than the number of the wisdom tooth region. This region was set to zero, while wisdom tooth region was set to one.
- Image multiplication: the image resulted from the last step was multiplied with ROI image before histogram equalization

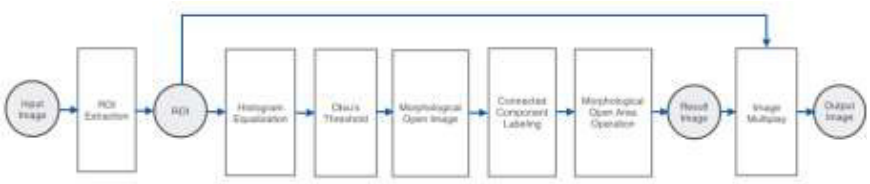
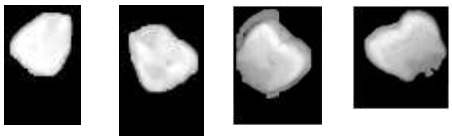


Fig (6): The main stages of the post-processing stage.

The final result is shown in fig. 7.



Fig,(7): The final result from post-processing.

3. Experiment Results

The proposed images succeed in extracting wisdom teeth in all panoramic images. The results from pre-processing showed that it enhanced the performance of the subsequent stages. Pre-processing is necessary stage in our proposed method and was not meant to enhance the image for the human observation.

The ROI was extracted successfuly in all images, the unwanted regions of the adjacent teeth were removed later in the post-processing (ROI Enhancement) stage. In final stage, an over and under segmentation accrued in some images.

3.1 Measuring Algorithm performance Using Mean Absolute Error

In Image segmentation, the mean absolute error (MAE) is a quantity measure how close measure how close the

segmented algorithm to the correct segmentation, it given by

$$MAE = \frac{1}{n}\sum_{i=1}^{n}|f_i - y_i| = \frac{1}{n}\sum_{i=1}^{n}|e_i|$$

Where f_i the result, and y_i the correct value. The MAE was perfumed using Matlab and it was 110.91 for tour proposed segmentation method.

3.2 Comparing Algorithm with other Similar Segmentation Algorithm

The proposed algorithm was compared with other algorithm according to input image type and the automation of the system and MAE, it showed that our method has the lowest MAE.

Table 1: Comparing the proposed algorithm with other teeth segmentation algorithm

	Dental Image Type	Work Type	MAE
Our Proposed Method	Panorama	Auto	110.91
Patanachai, N., et al. [6]	Panorama	Semi-Auto	131.75
Lira, P., et al. [7]	Panorama	Auto	116.01

4. Conclusion

The paper presents method to extract wisdom teeth automatically from panoramic images that consist from three stages, pre-processing ROI extraction and post-processing. The obtained results from the proposed method have shown that it could successfully extract the wisdom teeth, the segmented images can be used later in classification system to classify the extracted teeth as wisdom teeth or not, and then classify the wisdom teeth according to a specific problem i.e. impaction.

References

1. Rad, A. E., Rahim, M., Shafry, M., Rehman, A., Altameem, A. and Saba, T, "Evaluation of Current Dental Radiographs Segmentation Approaches in Computer-aided Applications", Institution of Electronics and Telecommunication Engineers Technical Review, (Medknow Publications & Media Pvt. Ltd.), 2013, Vol. 30, No. 3, PP. 210 - 222
2. Okechukwu Felix and Erondu , O. F. Medical Imaging, Rijeka, Croatia, InTech 2011.
3. Nelson, S. J. and Ash, M. M. "Wheeler's Dental Anatomy, Physiology, and Occlusion", 9th Ed, Missouri, US, Saunders Elsevier, 2010.
4. Dougherty, G. (2009), Digital Image Processing for Medical Applications, Cambridge, UK, Cambridge University Press.
5. Al-Sherif, N., Guo, G. and Ammar, H., "A New Approach to Teeth Segmentation," IEEE International Symposium on Multimedia, 2012 PP. 145 – 148.

6. Patanachai, N., Covavisaruch N. and Sinthanayothin, C. "Wavelet transformation for dental X-ray radiographs segmentation technique", 8th International Conference on ICT and Knowledge Engineering, IEEE, 2010 PP, 103 – 106.
7. Lira, P., Giraldi, G., Gilson, Neves, L. and Feijoo, R. "Dental R-Ray Image Segmentation Using Texture Recognition," Latin America Transactions, IEEE (Revista IEEE America Latina) 2014, Vol. 12, No. 4.
8. Barboza, E., Marana, A. and Oliveira, D. "A Multibiometric Approach in a Semi-Automatic Dental Recognition Using DIFT Technique and Dental Shape Features," SIBGRAPI 2012 - Workshop of Theses and Dissertations, 2012, PP. 13-18
9. Dougherty, G. (2009), Digital Image Processing for Medical Applications, Cambridge, UK, Cambridge University Press.
10. Gonzalez, R. C. and Woods, R. E. Digital Image Processing, 3rd Ed, Upper Saddle River, New Jersey, Prentice Hall, 2008.