2009 International Symposium on Intelligent Signal Processing and Communication Systems (ISPACS 2009) December 7-9, 2009

MP1-C-1

Improvement of the Detection Method for Carotid Artery Calcification in Dental Panoramic Radiographs

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Abstract- **This paper proposes improvement for the detection method for carotid artery calcification in dental panoramic radiographs. The existence of the carotid artery calcification as an index for arteriosclerosis attracts a great deal of attention. The detection method for carotid artery calcification has been proposed. However the detection rate is about 50% for real data and its improvement should be required. In this paper, the area of the processing window is narrowed to be 300 x 300 pixels. Then we focus on the shape and area of the target region and improve the detection and misdetection rates. From experimental results, the carotid artery calcification region can extract more precisely compared to the conventional method.**

I. INTRODUCTION

The blood vessel disease like as a stroke stands first rank in the cause of Japanese death and the main part of sudden death in Japan. It is discussed that the presence of the carotid artery calcification in dental panoramic radiographs can predict the risk of vascular diseases among old people [1]. A cause of sudden pathogenesis is that the calcification has no subjective symptom. Therefore a patient is hard to know it and loses the chance of check up. It is important to find early the symptom of the calcification for preventing the sudden pathogenesis.

In dental treatment, dental panoramic radiographs are often taken for the checkup. In this image, carotid artery next to the oral cavity is often included and the calcification in it is also found. Therefore by using an image for dental treatment, the dentist can find the presence of the calcification, explain the possibility of the blood vessel diseases to his patient and recommend consulting a physician. Then the sudden pathogenesis of the blood vessel diseases can be prevented.

A detection method of the carotid artery calcification on dental panoramic radiographs has been proposed [2]. This method is based on the slight difference of the intensities between the calcification region and its neighbor and uses fuzzy image contrast enhancement and algebraic image operator for overcoming the bad contrast of images. For the detection of the calcification region, this technique adopts the assumption where the carotid artery passes through the area between the outside of the spine and the outline of the throat. However several miss detections are occurred, since the edge of the calcification region can not detect correctly. This relates to the difference between the intensities of the calcification area and its surroundings. To ensure the suitable difference, the proper area size of the candidate region to be detected is required. This becomes one of the difficult problems in the algorithm.

To solve this problem, we divide this into the extractions of the candidate region from the whole image and the calcification region from the candidate one. In this paper, we focus on the latter and propose a new algorithm for the detection of the carotid artery calcification from the candidate region on dental panoramic radiographs. In this algorithm, it is assumed that the area of the candidate region in which the calcification can be extracted correctly is 300 x 300 pixels. The shape and area of the region are also taken into consideration. The difference of the intensity like Ref. [2] is also utilized in the proposed method. Therefore the fuzzy image contrast enhancement [3] is adopted. Experimental result shows the effectiveness of the proposed technique.

II. DETECTION METHOD BASED ON FUZZY IMAGE CONTRAST ENHANCEMENT

In this section, we apply the fuzzy image contrast enhancement to the detection of carotid artery calcification region in dental panoramic radiographs. The example of the image is shown in Fig. 1 and the target regions to be processed are indicated by white borders. Either region is used for the extraction of the carotid artery calcification region. In the following, extracting algorithm is described.

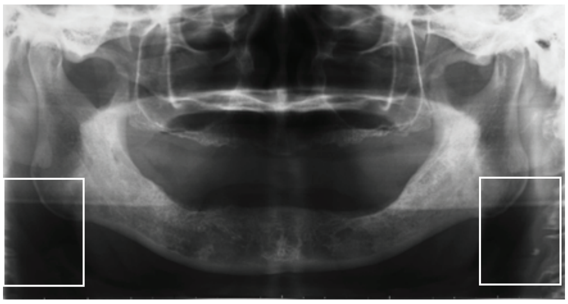

Fig.1 Example of a dental panoramic radiograph.

i) Transformation from an original image to the image on fuzzy domain

The original image is transformed to the membership value image on fuzzy domain by using the multi-mapping function [4] based on Gupta's sine wave function.

ii) Image enhancement on fuzzy domain

The enhancement operator proposed by De et al. [5] is used in this step, since its characteristic is easily modified and the operation can be completed once.

iii) Edge extraction in fuzzy domain

The algebraic image operator [6] is applied to the enhanced image for the edge extraction.

iv) Extraction of edges which enclose the object region

We assume that the carotid artery passes through the area between the outside of the spine and the outline of the throat. Naturally, the carotid artery calcification region exists in the same area. Next the longest edge is assumed as the outline of the spine, since the edges of the spine which is the longest bone in this region consist of many complex lines and curves. The second longest edge on the opposite side of the spine centering the object region is regarded as the outline of the throat, because this line has long but smoother curve compared to the outline of the spine. As a result, the object region can be extracted by the detection of the longest and second longest edges. Therefore, after the detection of the first and second longest edges by the labeling of the edge image, the reduced edge image which has only these edges is obtained. The region between these edges is considered as the object region.

v) Restoration of the intensities of the object region

On the reduced edge image, the pixels on the edges have 1 and otherwise 0. Then the bits of the reduced edge image are reversed and the bits of the regions which have the first and second largest areas are turned to 0. As a result, only the bits of the region between the first and second longest edges have 1. This mask image is multiplied by the original image. Then the image of the target region can be extracted.

vi) Edge extraction in the target region

The procedures from i) to iii) are applied to the image of the target region and the edge image of the target region is obtained.

vii) Edge extraction in the candidate region of the carotid artery calcification

The difference image between the edge images obtained from the procedure iv) and vi) is calculated and the edges in the candidate region of the carotid artery calcification are extracted.

viii) Restoration of the intensities of the candidate region of the carotid artery calcification

The intensities of the candidate region of the carotid artery calcification are restored by using the technique shown in the procedure v).

ix) Detection of the carotid artery calcification region

The carotid artery calcification region has brighter intensities than its neighbor region. Therefore the mean intensity is calculated from the candidate region and the regions which have darker intensities than the mean one are removed. Moreover the small reminded regions less than 200 pixels are also removed. This parameter is adopted by preliminary experiments.

In this method, some initial region which is expected to include the calcification region should be specified manually and the outline extraction of the spine and the throat is difficult. Therefore only five examples can be detected correctly among ten examples of the patient images. For the cases of the healthy person, it cannot work well.

III. PROPOSED METHOD

To improve the method proposed in Ref. [2], this method is divided into the extractions of the candidate region from the whole image and the calcification region from the candidate one. In this paper, the latter is focused on. Therefore, we assumed that the edges of the spine and throat can be extracted correctly. The calcification region exists between these edges. Since its intensity is higher than that of its neighborhood, 300 x 300 pixels area which has the brightest intensity is extracted as a candidate region of the calcification. In the following, the proposed extraction method of calcification region from this selected region is described. Note that some parameters in the following are obtained experimentally.

1) Selection of the candidate region

The candidate region is selected manually. Figure 2 shows an example of this. In this region, the existence of the calcification region is estimated. The size of this region is 300 x 300 pixels and the values of intensity are replaced to 0 excepting them from 20 to 150.

2) Edge detection by fuzzy image enhancement

The edge detection method [2] based on the fuzzy enhancement is applied for the candidate region. However the smoothing filter for the histogram is changed from the Savitzky-Golay filter to the median filter to avoid unnecessary smoothing effect. The excessive smoothing causes the deformation of histogram shapes and also the failure of the edge detection of the calcification region. Therefore the shape of the calcification region can be extracted from the image in which the conventional edge detection method cannot success it.

3) Removal of too large or small regions

By converting the intensities in the edge image and labeling, the sizes of the obtained regions are calculated. It is assumed that the calcification region exists in the carotid artery and has a size in a certain extent. In this case, the regions whose sizes are greater than 1700 pixels or less than 50 pixels are removed.

4) Restoration of residual regions

The shape of the region obtained by Step 3 is not always consistent to that of the calcification region. Based on the obtained regions, the candidates of the calcification region are restored. However the position of the correct region cannot know at this point, then all the residual regions are restored. The labeling is applied to the image and, according to its label number, the image for each region is generated. In each image, the position and intensity of the pixel which has the maximum intensity are obtained. From this position, the pixel position whose value is over 0.85 times the maximum intensity is looked for toward up, down, left and right direction. The rectangle with sides which pass the found positions is considered and the pixels whose values are over 0.85 times the maximum intensity in it are restored.

5) Removal of too large regions in the vertical length

Like Step 3, too large regions in the vertical length are deleted. Since the calcification region exists in the carotid artery, its shape is considered to be the appropriate length region in the vertical one. Accordingly the regions with over 70 pixels in the vertical size are removed. The regions which overlap the side edges of images are also deleted. After the removal processing, each region image is integrated into an image.

6) Removal of too small regions and holes

The regions with the area size under 200 pixels are deleted. For holes filling, by reversing the intensities in the image and labeling, each region size is calculated and the region having less than 100 pixels is removed. The intensities of the removed image are reversed again.

7) Extraction of the long region in the vertical length

Like Step 5, each region is extracted as an image and the outline and gravity center of the region are found. The gravity center is considered as the center of the region. Then the lengths of the height and wide are calculated. Based on these ones, the long region in the vertical length is restored and other regions are removed. Finally each processed image is integrated as the resulting calcification region image.

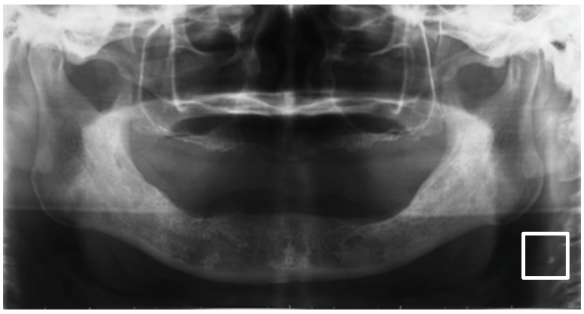

Fig. 2 Example of the candidate region on the dental panoramic radiograph.

IV. EXPERIMENTAL RESULTS

To show the effectiveness of the proposed method, some experimental results are shown. Figure 3 and 4 show dental panoramic radiographs which have a calcification region in the carotid artery. In these figures, the regions enclosed by the white circle are the carotid artery calcification ones which are identified by a dentist. The obtained results are shown in Figs. 5 and 6 which are correspond to Figs. 3 and 4. In Fig. 3, we can detect the calcification region successfully, especially only the calcification region is extracted. Fig. 4 can also be detected the calcification region but the wrong one.

Figure 5 is also the dental panoramic radiograph which includes the calcification region and Fig. 6 shows its edge image, however this example shows the case where we cannot find the calcification region. In this case, we failed the detection of the region of the carotid artery calcification, since the result of the edge detection was too complicate to extract the shape of the candidate.

We applied the proposed technique to twenty dental panoramic photographs which are ten images include the carotid artery calcification and ten do not include it. We can detect the carotid artery calcification for eight images. In these results, only the calcification region was extracted for six images and two images included the wrong region. However last two images cannot success to find it. For the case of the healthy person, all images can be judged correctly. In Ref. [2], only five examples can be detected correctly among ten patient images. Compare to the method proposed in Ref. [2], the proposed method can improve both detection rate of the calcification region for the patients and healthy ones.

V. CONCLUSION

This paper has proposed improvement of the detection method of the carotid artery calcification which is found in dental panoramic photographs. The proposed method is based on the detection method proposed by Ref. [2] which has adopted fuzzy image contrast enhancement and algebraic image operator. In this case, the area size of the candidate region has been restricted a rectangle with 300 x 300 pixels and simultaneously the shape and size assumptions of calcification have been applied. The experimental results show that we successfully detect the calcification region from eight images among ten images with it and that no region is detected it from the images of the healthy person.

The proposed algorithm selects the candidate region manually, however fully automated detection should be preferable. The automatic selection of the candidate region is left for the future work. The refinement of the detection algorithm is also left for the future work, since the detection is failed for two images. Especially the sophisticated edge detection for low contrast and complicated edges is required.

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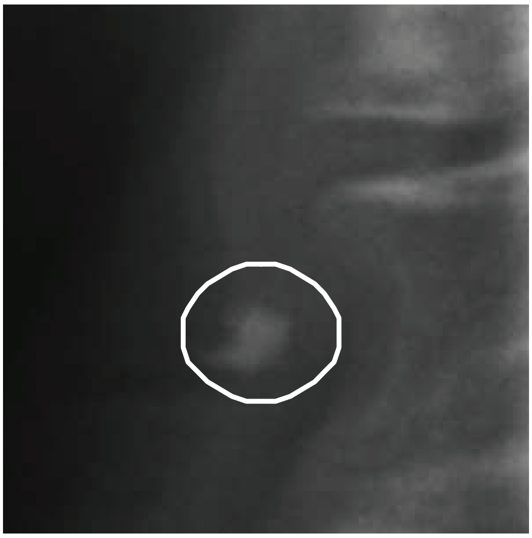

Fig. 3 Example 1.

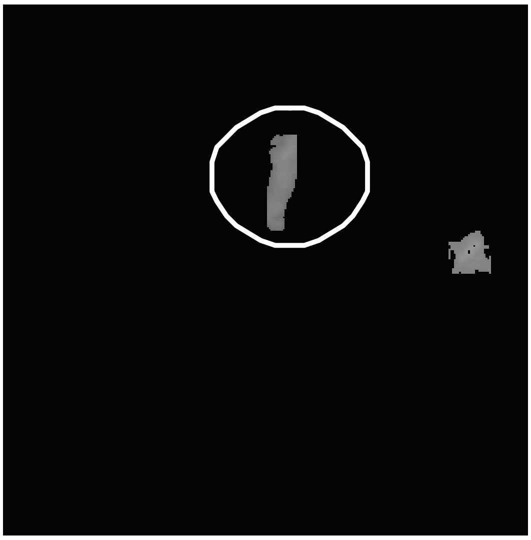

Fig. 6 Detection result of Example 2.

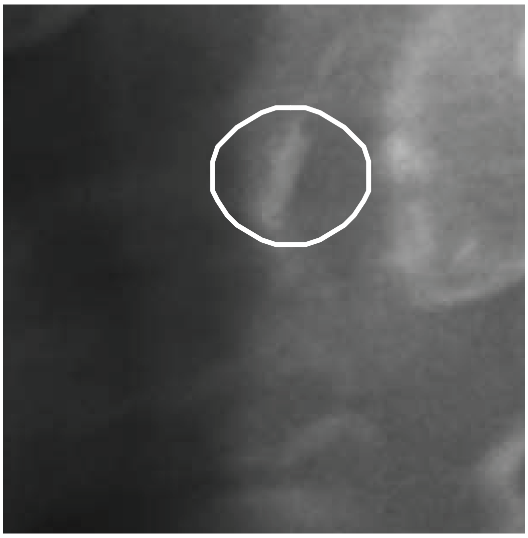

Fig. 4 Example 2.

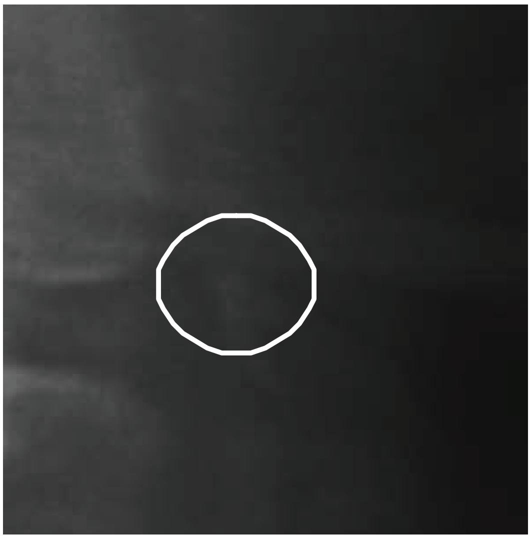

Fig. 7 Example 3.

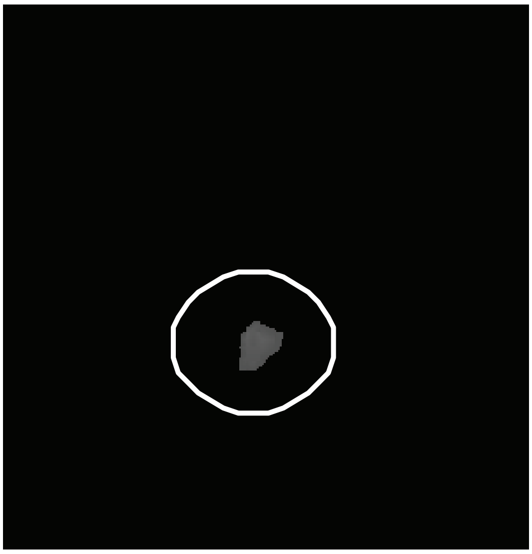

Fig. 5 Detection result of Example 1.

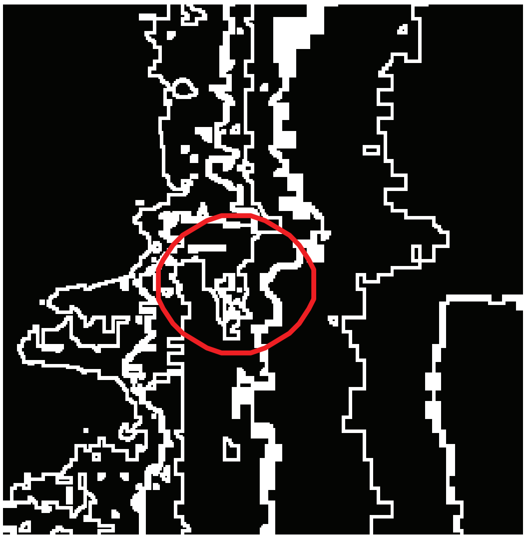

Fig. 8 Edge image of example 3.