CONSTRAST ENHANCEMENT OF STROKE LESIONS IN CT HEAD IMAGES

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Abstract

The paper presets a method for a contrast enhancement of stroke lesions in the computed tomography (CT) head images. The method consists of three filters used consecutively. The first filter is 5x5 average filter, the second filter is 21x21 adaptive averaging filter and the third filter is 3x3 unsharp filter. The method is demonstrated on the CT head image containing a large stroke lesion. The results of the method are evaluated visually. The presented method improves delectability of the stroke lesion. The noise level is also significantly reduced.

1 Intoduction

X-ray computed tomography (CT) is the most common imaging method for investigation of patients with suspected brain stroke. Nowadays the CT machine is available in almost every hospital, and a large database of the CT images have been collected in the hospitals over the past years. The possibility of an automated processing of the images could improve our knowledge of the brain stroke. First step in order to successfully process the images is an automated detection of the stroke lesions. The detection is difficult since the CT images are very noisy. The paper presents a method capable of contrast enhancement of the stroke lesions in CT images. After the enhancement the lesions are clearly visible and susceptible to the thresholding or other image processing methods for object detection.

The regularly used linear filters for a noise reduction or a contrast enhancement are not optimal for the detection of the stroke lesions in CT images. In order to filter very noisy CT images high order linear filters are required. The edges of the stroke lesions in the images can be smoothed by the high order linear filters [1]. Such a smoothing is not optimal for an accurate stroke lesion detection in CT images. The presented method is a combination of the low order linear filters with an adaptive filtering method capable of preserving of the edges and removing the large portion of the noise.

Smoothing techniques for biomedical images have been extensively studied in the last few decades [2] [3] [4]. The method is based on the paper by Du-Yih Tsai in 2005 which presented enhancement filtering for CT brain images [5]. The enhancement filter required extensive calculation for setting the threshold of the filter and results of the enhancement depended greatly on the threshold setting. In the method presented in this paper the threshold is set by visual observation and the method is extended by usage of unsharp filter. The usage of unsharp filter allows less accurate setting of the threshold and the results are less dependent on the threshold setting.

2 Method and Implementation

The method has been tested on 2D image selected from the set of head images obtained by the computed tomography device. The selected image has a large stroke lesion visible by a naked eye. The method consists of applying three consecutive filtering methods. The first filtering method is an 5x5 average filter, the second is an 21x21 adaptive averaging filter, and the last is an unsharp filter. The method is based on paper [5] and the main difference is the usage of an unsharp filter.

2.1 Adaptive Averaging Filter

The first step of the method is applying a 5x5 averaging filter to the image. The second step is usage of an adaptive averaging filter. First a binary mask has to be determined. Each pixel (*m,n*) of the image I is assigned a 21x21 window W centered on the pixel. The point *I(k,l)* in the binary mask of the size W is assingned a value zero if:

$$|I(k,l) - I(m,n)| > t \tag{1}$$

otherwise the point is assigned value one. The pixel P(m,n) in the processed image is obtained as:

$$P(m,n) = M(m,n) \tag{2}$$

where *M(m,n)* is the mean value of the pixels from image I labeled by the determined binary mask as ones. The calculated mask depends highly on a selected threshold t. [5] In this method the threshold is selected manually using only small number of visual iterations.

2.2 Unsharp Filter

The common method for the sharpening of an image is adding a high passed version of the image. This results in the enhance version of the given picture. [6] The 3x3 unsharp filter is used in the method and the filter impulse response h is given by:

$$h = \frac{1}{\alpha + 1} \begin{bmatrix} -\alpha & \alpha - 1 & -\alpha \\ \alpha - 1 & \alpha + 5 & \alpha - 1 \\ -\alpha & \alpha - 1 & -\alpha \end{bmatrix} \tag{3}$$

where the α is set to 0.2.

3 Results and Discussion

The original image before any filtering is shown in Figure 1. It is clearly visible that the image is noisy. The stroke lesion is difficult to be distinguished from the surrounding brain tissue.

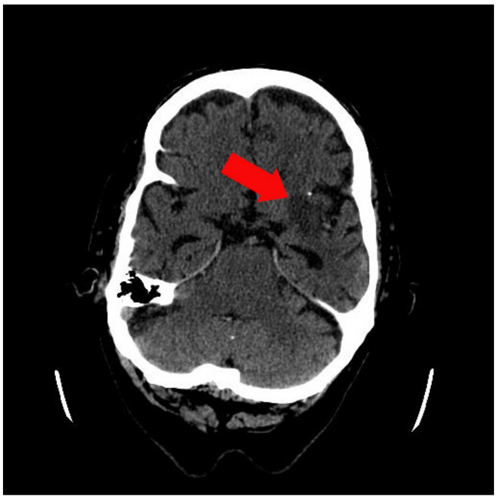

Figure 1: Computed tomography image containing the stroke lesion before applying the filtering methods. The stroke lesion is poited out by the red arrow.

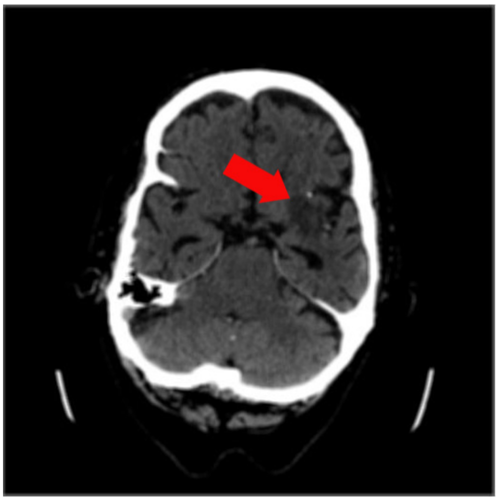

Figure 2: Computed tomography image containing the stroke lesion after applying the 5x5 average filter. The stroke lesion is poited out by the red arrow.

The image after applying the 5x5 average filter is shown Figure 2. It can be seen that the image is less noisy but the edges are less sharp than in the original image. The ability to distinguish between brain tissue and stroke lesion has not improved.

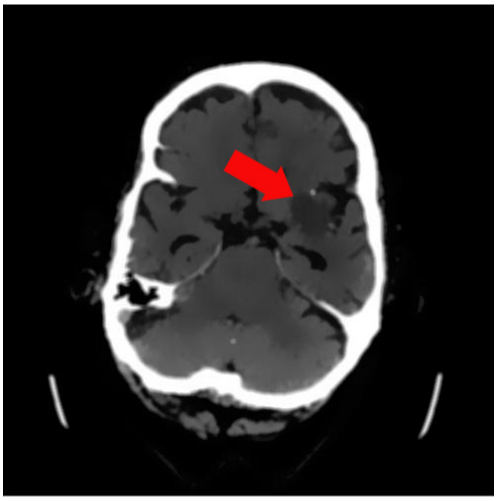

Figure 3: Computed tomography image containing the stroke lesion after applying the adaptive average filter. The stroke lesion is poited out by the red arrow.

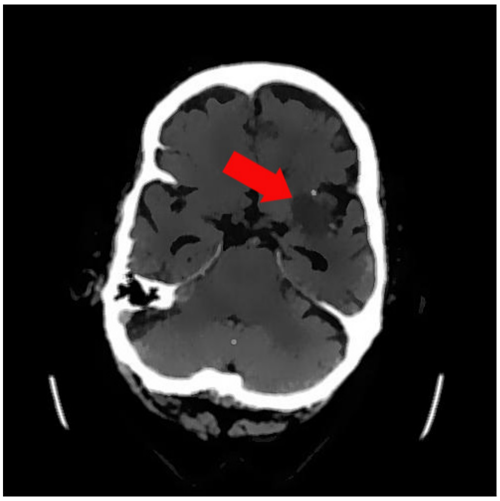

Figure 4: Computed tomography image containing the stroke lesion after applying the unsharp filter. The stroke lesion is poited out by the red arrow.

The image after applying the adaptive average filter is shown Figure 3. It is visible that the noise is almost completely removed. The brain tissue and the stroke lesion is visibly separated and can be distinguished easily by a naked eye. But the edges of the brain tissue and the stroke lesion are still blurry.

The image after applying the unsharp filter is shown Figure 4. The edges have improved significantly and there is a sharp boundary between the stroke lesion and the brain tissue.The image after applying the unsharp filter is shown Figure 4. The edges have improved significantly and there is a sharp boundary between the stroke lesion and the brain tissue.

4 Conclusion

The filtering method presented in the paper was applied to the CT head image containing the stroke lesion. The results have been analyzed visually. The method was able to enhance differences between the brain tissue and the stroke lesion. The delectability of the stroke lesion was improved by the method. The noise level in the CT image was also reduced. The usage of unsharp filter in the last step improved the results significantly.

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