

Fuzzy Based Contrast Enhancement Method for Lung Cancer CT Images

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Abstract: *Computer aided diagnosis (CAD) has become most commonly used tool in the diagnosis and analysis of medical images such as Lung cancer detection, Brest cancer detection etc. Different type of medical image modalities are used in the diagnosis process by radiologist and physician such as radiographic images ,computer tomography (CT) images, magnetic resonance images (MRI), positron emission tomography (PET) etc. In all analysis if the image quality is not proper then the performance of the CAD system is adversely effected. This work proposed a new Background suppressed fuzzy contrast enhancement (BSFCE) method to improve contrast of the CT images of lung cancer patient. The performance of proposed method have been extensively evaluated and compared with the two existing contrast enhancement techniques Histogram Equalization (HE) and Adaptive Histogram Equalization (AHE) techniques in terms of Mean, Variance and Contrast-per-pixel (CPP).The results reflects that the proposed method outperforms the HE and AHE techniques.*

Keywords: *Computed tomography (CT), lung cancer, medical image, Background suppress fuzzy contrast enhancement (BSFCE)), histogram equalization (HE), adaptive histogram equalization (AHE)..*

1. Introduction

From 1972 when computed tomography (CT) was introduced, its use has mostly substituted many imaging methods which have been inadequate in representing anatomy, pathology and more aggressive diagnostic checks[1]. The new technique like CT gives wide range of contract information as compare to normal X-ray film. Image de-noising or image enhancement is an appropriate technique that could help in removing or reducing the amount of noise mixed with the digital images [2-6].Lung cancer is one of the most serious cancers in the world, with the smallest survival rate after the diagnosis, with a gradual increase in the number of deaths every year. Survival from lung cancer is directly related to its growth at its detection time. If detection is done earlier, the higher the chances of successful treatment are. An estimated 85% of lung. CAD system for early detection of lung cancer helps on an automatic diagnosis of the lung nodule included in chest CT .The problem for detecting lung nodules in radiographs include variation in nodule size, appearing anywhere in the lung area, nodule appearance may same as bone etc. [7-8].

Jiping (2016) evaluate the value of contrast enhancement in terms of mean density and enhancement extent of lesions for the 26 patients with respect to pretreatment value P significant reduced (p=0) after effective treatment of patients. Very close investigation is required[3] .

Sinha et al. (2015) proposed a non-linear method for removing salt and paper noise using modified fuzzy based decision algorithm for gray images only. However fuzzy filter can be design to remove all type of noise from images[5]. Sandeep et al. (2014) proposed contrast limited Adaptive Histogram Equalization for preprocessing of images. But the time taken could be reduce for feature extraction of images[7].

Surya et al. (2015) compared two contrast enhancement methods Adaptive Histogram Equalization (AHE) and

Brightness preserving bi histogram Equalization (BBHE) with respect to their PSNR and MSE.AHE fails to retain its brightness[12]. Bhagwati et al. (2015) discussed among Histogram Equalization, Histogram Specification and local Enhancement techniques for contrast enhancement of mammographic images and calculate their SNR(signal to noise ratio) and RMSE (root mean square error) but the other technique may also be checked for better result[11].

Ashwin et al. (2012) suggested a CAD system for the lung nodule detection using neural network. The contrast limited adaptive histogram method was used to remove the noise presented in medical image and improve the contrast, However the brightness value could be further increase[22]. Borra et al. (2015) used Brightness Preserving Bi Histogram Equalization and Adaptive Histogram Equalization methods for contrast enhancement which divide image histogram in two parts mean and median and then process is performed[24]. Cuifang et al. (2012) performed some investigation over fuzzy enhancement algorithm for pulmonary nodules and the result shows that this method improve the contrast of image on some extent and also reduce the blood vessel disturbing problem[25].

2. Proposed Method

Histogram Equalization (HE) and Adaptive Histogram Equalization (AHE) are two conventional method to improve the contrasts in an intensity image. Histogram equalization is used widely to enhance the contrast of images in a various applications because of its simple function an effectiveness. A calculation of histogram done only for those pixels which are covered by the mask. Inside the mask the centre pixel will then be written to the resulting image. Then mask is moved one pixel towards right and compute a new histogram . For each row this process is continue for each pixel of image[11]. Histogram equalization mapping function supported over a certain size of a local window to determine each enhanced

density value. It acts as a local operation. Therefore regions occupying different gray scale ranges can be enhanced simultaneously. The HE method is useful where backgrounds and foregrounds of images are both bright or both dark[26].

Adaptive histogram equalization divided the image into many rectangular domains, compute an equalizing histogram and modify levels so that they match across boundaries. Depending on the nature of the non uniformity of the image. Adaptive histogram equalization uses the histogram equalization mapping function supported over a certain size of a local window to determine each enhanced density value. Adaptive Histogram Equalization (AHE) method is particularly useful, where, both background and foreground are dark and represented by a set of narrow gray values hence we need effective technique which can enhance the bimodal histogram images.

The limitation of HE and AHE techniques lies on the fact that both perform well for single modal histogram images but the CT images of lung cancer false on the category of bimodal histogram, but the performance of both the techniques are poor. Several work has been done on contrast enhancement still more accuracy is needed. Here we are proposing the new method Background suppressed fuzzy contrast enhancement (BSFCE) to increase the contrast of input CT images.

The first step to collect lung CT images for preprocessing which is used to improve the image in terms of enhancing contrast, removing noise etc. Segmentation refer to the process of partitioning digital image into different classes such as edge detection ,histogram thresholding, ANN and clustering technique. Post processing used to remove many false regions as possible and the nodules are classified as per their properties. CT images of the lungs are often very low in contrast, which is evident from their histograms that are narrow and concentrated only to certain gray level values. However, lung images contain minute details of the get obscured due to limited contrast, and hence, are not easily presented before doctors. This may lead to delayed diagnosis and even wrong treatment. Histogram equalization plays an important role in several such cases, however, while leaving local changes in contrast, unconsidered[22]. The projected CAD system involve the following steps as shown in Fig1

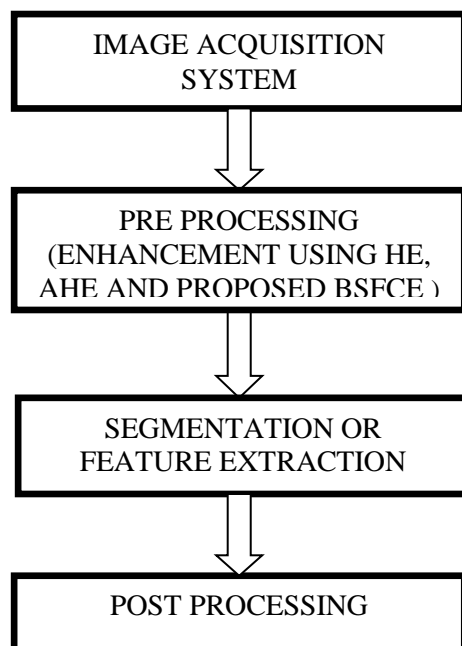


Fig1: A typical CAD system

Following are the steps of proposed BSFCE algorithm.

Step1. Apply background suppression of input image.

(a) Apply morphological opening operation to identify the background of the input CT scan image.

(b) Subtract the extracted background from the input CT scan image to get the foreground information.

Step 2. Now to calculate X_{max} set the parameters F_e, F_d .

$$F_e = 0.7, \quad F_d = \frac{X_{max} - X_{mid}}{0.5^{F_e} - 1}$$

Where F_e, F_d are constants for image Fuzzification, and

X_{max} = Maximum gray value of input image.

X_{mid} = Mid gray value of input image.

Step 3. Define the membership function for Fuzzification .

$$\mu_{mn} = G(X_{mn}) = \left[1 + \frac{X_{max} - X_{mn}}{F_d} \right]^{-F_e}$$

Where μ_{mn} is membership function.

Step 4. Using contrast intensification operator on fuzzy sets modify the obtained membership values [27].

$$\mu'_{mn} = \begin{cases} 2[\mu_{mn}]^2, & 0 \leq \mu_{mn} \leq 0.5 \\ 1 - 2[1 - \mu_{mn}]^2, & 0.5 \leq \mu_{mn} \leq 1 \end{cases}$$

Step 5. By Defuzzification process generate new gray levels of contrast intensified membership values.

$$g'_{mn} = G^{-1}(\mu'_{mn}) = X_{max} - F_d \left((\mu'_{mn})^{\frac{-1}{F_e}} \right) + F_d$$

3. Result and Discussion

In case of Bimodal Histogram image the mean and contrast per pixel (CPP) value must be close to the original value of input image because any increase in both the quality will generate artifacts or distortion in the enhance image if both the value were increase that means that the enhancement technique tries to convert bimodal into single modal histogram. To overcome the drawback of conventional techniques like HE and AHE and perfectly solve this issue we need a technique which can enhance the image by maintaining the bimodal characteristic of original image and simultaneously able to keep mean and CPP value closer to original image after enhancement. The proposed method Background suppress fuzzy contrast enhancement (BSFCE) will overcome the above problem and gives good contrast of input image.

A database of 100 images was formed. All the lung cancer images are taken from Pt, J. N. U. medical college hospital cancer unit of Raipur. Figure 2 and 3 shows an input images of lungs after denoising using wiener filter and compare result of three contrast enhancement methods HE, AHE and proposed method BSFCE over input images with respect to the parameters Mean , Variance and CPP to improve the image quality.

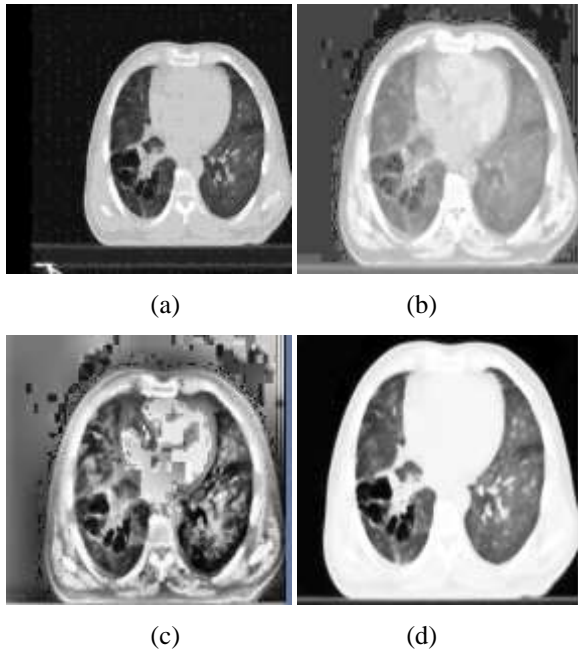


Fig 2: Enhanced output images (a) Input image (CPW1)
(b) HE output (c) AHE output (d) BSFCE output

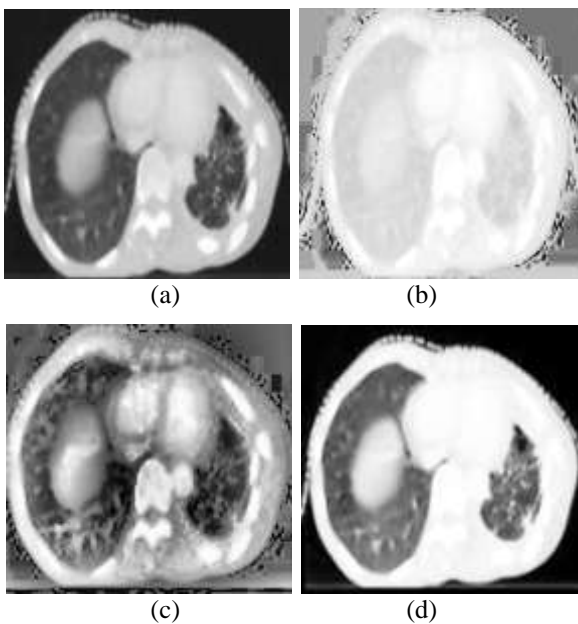


Fig 3: Enhanced output images (a) Input image (CPW9)
(b) HE output (c) AHE output (d) BSFCE output

Finally, after comparing the result of HE and AHE in terms of Mean, Variance and CPP for CT images with our proposed algorithm background suppress fuzzy contrast enhancement (BSFCE) we can conclude that the BSFCE is better than HE and AHE in our CT images.

Table 1: Comparison of Mean, Variance and CPP for CT images

	Mean	Variance	CPP
Input Image(CPW1)	88.72	6200.42	11.15
HE	127.67	5500.99	16.06
AHE	126.34	3533.52	16.02
BSFCE (Proposed)	95.52	9764.26	11.98
Input Image(CPW9)	46.69	3460.02	5.86
HE	126.83	5393.89	15.95
AHE	117.03	2116.42	14.85
BSFCE (Proposed)	37.56	5713.85	4.69

4. Conclusions

In this paper, an attempt to compare two enhancement methods HE and AHE with proposed method BSFCE for increasing contrast of input images for better output. We can conclude with the parameters value of mean, variance and contrast per pixel from Table 1 that our method BSFCE mean and CPP values are near to input image values but value of variance is higher than Input, HE and AHE Images which is good for bimodal nature of image. Hence our proposed method is giving better contrast which is helpful to segment the affected region with proper area for detection of lung cancer.

References

1. Z. Al Ameen, S. Al-Ameen and G. Solong, "Latest Methods of Image Enhancement and Restoration for Computed Tomography: A Concise Review" Applied Medical Informatics, Vol. 36, pp. 1-12, 2015.
2. J. B. Zimmerman, S. M. Pizer, Edward V. Staab, J. Randolph "An Evaluation of the Effectiveness of Adaptive Histogram Equalization for Contrast Enhancement" IEEE Transaction on medical imaging, Vol. 7, Dec 1988.
3. J. Yu, H. Liu, H. Chen, S. Ren, "The value of contrast-enhanced computed tomography in evaluating patient response to Icotinib for non-small cell lung cancer" Biomedical Research, Vol 7(3), pp. 905-911, 2016.
4. A. Caudhary and S. S. Singh, "Lung Cancer Detection On CT Images By Using Image Processing" IEEE Transaction, pp. 142-146, 2012.
5. G. R. Sinha and N. Agrawal, "Fuzzy based Image Enhancement Method", IJCA, pp. 13-18, 2015.
6. G. R. Sinha and Y. Bahendwar, "Efficient Algorithm For Denoising Of Medical Images Using Discrete Wavelet Transforms" Mathematical Methods and Systems in Science and Engineering, pp. 158-161.
7. S. A. Dwivedi, R. P. Borse, A. M. Yametkar, "Lung Cancer Detection and classification by using Machine Learning and Multinomial Bayesian" IOSR Journal of Electronics and Communication Engineering, Vol 9, pp. 69-75, Jan 2014.
8. D. Sharma and G. Jindal, "Computer Aided Diagnosis System for Detection of Lung Cancer in CT Scan Images" Vol 3, pp. 214-218, Oct 2011.
9. I. Islam Wani, M. C. Hanumantharaju, M. T. Gopalakrishna, "Review of Mammogram Enhancement Techniques for Detecting Breast Cancer" IJCA, pp. 14-18, 2014.
10. R. Sumalata and M. V. Sbramanyam, "Image Denoising Using Spatial Adaptive mask Filter for Medical images", IJECE, Vol 1, Jan 2014.

11. B. C. Patel and G. R. Sinha, "Histogram based Contrast Enhancement Method for Mammographic Breast Images", IJCA, pp. 25-28, 2015.
12. S. P. Rao Borra, R. K. Panakala and P. Rajesh Kumar "Contrast Enhancement of Low Dose CT Scan Images", IJCTA, Vol 8(5), pp. 2415-2422, 2015.
13. F. Shahsavari, Alavijeh, Homayoun and Mahdavi-Nasab "Multi-scale Morphological Image Enhancement of Chest Radiographs by a Hybrid Scheme" Journal of Medical Signals & Sensors, Vol 5, pp. 59-68, Mar 2015.
14. Shaik, Rajni, Arivuselvan and T. Sreenivansulu "Early Stage Detection Of Breast Cancer Using Feature extraction technique" International Journal of Pharma and Bio Sciences Vol 7(2), pp. 26-33, Apr 2016.
15. G. R. Sinha and B. C. Patel, "Medical Image Processing: concepts and applications", Prentice Hall of India, 2014.
16. O. S. Al-Kadi, "Assessment of texture measures susceptibility to noise in conventional and contrast enhanced computed tomography lung tumor images" Computerized Medical Imaging and Graphics, pp. 494-503, 2010.
17. B. C. Patel, G. R. Sinha and K. Thakur, "Early Detection of Breast Cancer using a Modified Topological Derivative Based Method", International Journal of Pure and Applied Sciences and Technology, pp. 75-80, 2011.
18. Anil and R. D. Patane, "Lung Cancer Detection and Classification by using Bayesian Classifier" Proceedings of IRF International Conference, pp. 7-13, Feb 2014.
19. B. Gupta and S. Tiwari, "Lung Cancer Detection using Curvelet Transform and Neural Network", IJCA, Vol 86, pp. 15-17, Jan 2014.
20. R. Sharma and G. Jindal, "Contrast Enhancement using modified fast Haarwavelet transform (MFHT) on Lung cancer images" IJIT, Vol 2, pp. 184-189, apr 2013.
21. P. Shanmugavadivua and V. Sivakumar, "Fractal-Based Detection of Micro calcification Clusters in Digital Mammograms", ICECIT, pp. 58-63, 2012.
22. S. Ashwin, S. A. Kumar, J. Ramesh, K. Gunavathi, "Efficient and reliable lung nodule detection using a neural network based computer aided diagnosis system", IEE Proceeding International Conference of Emerging Trends in Electrical Engineering and Energy Management (ICETEEEM), 2012.
23. D. Chung Chang and W. Rong Wu, "Image Contrast Enhancement Based on a Histogram Transformation of Local Standard Deviation" IEEE Transaction on Medical Imaging, Vol 17, pp. 518-531, Aug 1998.
24. S. P. R. Borra, R. K. Panakala and P. R. Kumar, "Contrast Enhancement Low Dose CT Scan Images", International Journal of Computer Theory and Application, Vol. 8, No 5, pp. 2415-2422, 2015.
25. L. Cuifang, N. Shengdong, and W. Yuanjun, "Experimental Investigation of Fuzzy Enhancement for Nonsolid Pulmonary Nodules", IEEE symposium on robotics and application (ISRA), pp. 756-759, 2012.
26. Ritika and S. Kaur, "Contrast Enhancement Techniques for Images—A Visual Analysis", International Journal of Computer Applications, Vol. 64, No. 17, pp. 20-25, 2015.
27. P. Mishra and K. L. Sinha, "A Highly Efficient Color Image Contrast Enhancement using Fuzzy Based Contrast Intensification Operator", Advanced Research in Electrical and Electronic Engineering, Vol. 1, No. 4, pp. 26-31.