Qualitative Improvement in Wireless Capsule Endoscopy Images using Specific Contrast Enhancement Techniques

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ABSTRACT-Wireless Capsule Endoscopy (WCE) is a non-invasive as well as an innovative solution for the detection of gastrointestinal diseases especially for small bowel diseases, such as polyps that is a main cause for gastrointestinal bleeding. The quality in these Wireless Capsule Endoscopy (WCE) images is very critical for diagnosis. The image quality is often affected with noise or degradation in acquiring and also during illumination condition. This paper presents a method to enhance the visual quality of WCE images. In this paper to improve the quality of WCE images, contrast stretching is first used to adjust the contrast of the input image. Next, Contrast Limited Adaptive Histogram Equalization (CLAHE) technique is employed. Then, at last unsharp filtering is done to sharp the image. This yields the enhanced image which is highly improved in quality. The enhanced image highlights the details and improves the overall contrast, which is helpful for diagnosis.

Keywords— Wireless Capsule Endoscopy, WCE, CLAHE, unsharp filtering

1. INTRODUCTION

Digital images play a vital role in so many applications such as satellite television as well as in areas of research and technology such as geographical information systems etc. [1]. When an image is converted from one form to another, some form of degradation occurs at processed image. Improvement in quality of images which are degraded can be done by applying one of the enhancement algorithms. These enhancement techniques are obviously application specific. Image enhancement methods emphasize specific features to improve the visual perception in an image. Image enhancement yields an output image by varying the pixel‘s intensity of the input image [2].

Enhancement is basically improving the interpretability or perception of information in the images for viewers and providing much better input for other automated image processing techniques. There exist many methods that can improve a digital image without spoiling it [3]. It will be a developing trend to integrate the advantages of many algorithms to practical application to image enhancements [4].

Medical imaging is concerned with the development of the imaging instruments that aid to identify different aspects of the tissue and organs based on different properties and reveal new properties of the tissue and internal structure [5]. Medical image processing is a field of science and is gaining wide acceptance in healthcare industry because of its technological advances and software breakthroughs. It plays a critical role in disease diagnosis and in improved patient care [5].

These operations are performed in order to alter brightness, contrast or the distribution of the grey levels in image. The pixel intensities of the output image are modified according to the transformation function applied on the input values. Image enhancement is applied in every field where images are ought to be understood and analyzed. For example, medical image analysis, analysis of images from satellites etc [6].

This paper is organized as follows; Section 2 gives a brief review of previous related work and WCE imaging. Section 3 describes the proposed design methodology. Performance evaluation is presented in Section 4. Results are presented in Section 5. Conclusion is presented in Section 6.

2. RELATED WORK AND BACKGROUND

In this section, previous related work and the WCE device are explained.

Related work and contributions

Manvi, in her paper used histogram equalization for contrast enhancement in the image. Contrast enhancement methods vary the image through some pixel mapping such that the histogram of the output image is more spread than that of the original input image. The purpose of histogram equalization is to produce a uniform histogram. This operation is carried out by effectively spreading out the most frequent intensity values. Histogram equalization technique is more useful when the images with foregrounds and backgrounds that are both bright or both dark [13].

Indira et al. presented an algorithm for medical image enhancement in two stages. The first stage corrects the contrast of an image and in the second stage wavelet fusion has applied for enhancement of medical image. The restored images using this method are generally not satisfactory since the two steps adapted in this work over enhance the image. Therefore, this scheme may not be suitable for medical image enhancement [14].

R. Senthil kumar et al, in his paper presented an analysis of image enhancement techniques i.e., HE, AHE, CLAHE histogram modification methods to enhance Chest X-ray images and these are implemented in MATLAB. The performance in these algorithms is compared by using parameters like Peak signal to noise ratio (PSNR), Mean squared error (MSE), Signal to noise ratio (SNR), Absolute mean brightness error (AMBE) and Entropy. From these experimental results; and it was shown that CLAHE was

competent when compared to other techniques. CLAHE was at first developed for medical imaging and has confirmed to be successful to improve low-contrast images like x-ray images and portal films [15].

Sundaram et al. presented a histogram modified local contrast enhancement for mammogram images. This method offers better contrast enhancement and preserves local information in the mammogram images. In addition, this method leads in the detection of micro-classifications presence in the mammogram image. However, the method works well for mammogram images but it fails to produce satisfactory results for other medical images [16].

Wireless Capsule Endoscopy

Conventional endoscopy often presents limitation during diagnosis ofsmall bowel diseases, because it is limited to the upper gastrointestinal (GI) tract, at the duodenum, and to lower GI tract, at terminal ileum. Therefore, prior to the invention of Wireless Capsule Endoscopy (WCE), the small intestine was the conventional endoscopy‘s last frontier, since it could not be internally visualized directly or in entirely by any techniques [7]. Wireless capsule endoscopy (WCE) is a new technology to diagnose the gastrointestinal tract problems with practicallyno invasiveness [8].

Wireless capsule endoscopy (WCE) is a disposable small capsule which helps to visualize the small bowel and to trace the abnormalities of the small bowel. This tiny capsule is capable to transmit color and high fidelity images of the entire gastrointestinal tract, and also intestines [9]. These WCE products have approved by the Food and Drug Administration (FDA) [10, 11]. This WCE device can be used to trace more diseases like obscure gastrointestinal bleeding, suspected Crohn‘s disease, chronic unexplained diarrhea, screening and surveillance for small bowel polyposis, etc. [12]. But WCE image quality is often affected with noise or degradation. Thus, the quality improvement in these images is needed in WCE medical applications.

3. PROPOSED METHOD

This section presents the proposed design methodology for the enhancement of WCE image. The flow sequence of the proposed design technique is shown in fig.1.

Contrast Stretching Operation

The input is the low contrast image which is to be enhanced. This image may have random pixel range. Therefore, contrast stretching operation is accomplished in order to translate the pixels in the display range of 0 to 255 [3].

Contrast Limited Adaptive Histogram Equalization

CLAHE operates on small regions in the image, called tiles, unlike histogram equalization, which operates on the entire image. Each tile's contrast is enhanced, such that the histogram of the output region approximately nearer to the histogram specified by the 'Distribution' parameter. The neighboring tiles are then combined by using bilinear interpolation for eliminating artificially induced boundaries. The contrast, mainly in homogeneous areas, can be limited for avoiding amplification of noise which might be present in the image. The value at which the histogram is clipped, the so-called clip limit, depends on the normalization of the histogram and thereby on the size of the neighborhood region. The CLAHE is a contrast-enhancement method that works significantly better than regular histogram equalization for most images [3].

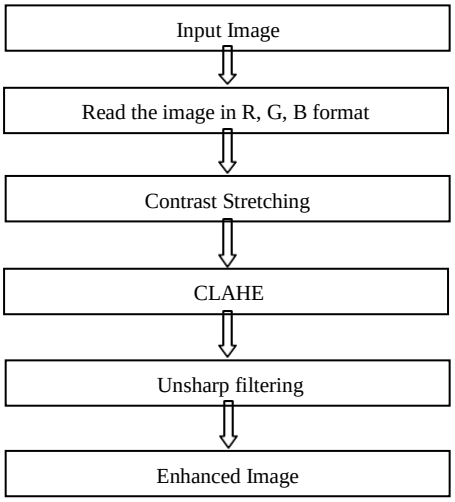

Fig. 1: Flow Sequence of the Proposed Method

Unsharp Filtering

An unsharp filter is an image sharpening operator [3]. This is one of the common techniques used for contrast enhancement. This provides better results after performing CLAHE operation. This is the final operation to get enhanced image.

4. PERFORMANCE EVALUATION

In this paper, the proposed design algorithms are implemented by using MATLAB R2013a. Performance analysis techniques require extraction of certain features that help in the identification of the object. There are many measures for quantitative analysis such as Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR) etc. In this paper, PSNR, MSE, SSIM are used for performance analysis.

5. RESULTS

The results of improved WCE image compare to input image is shown in Fig 2.

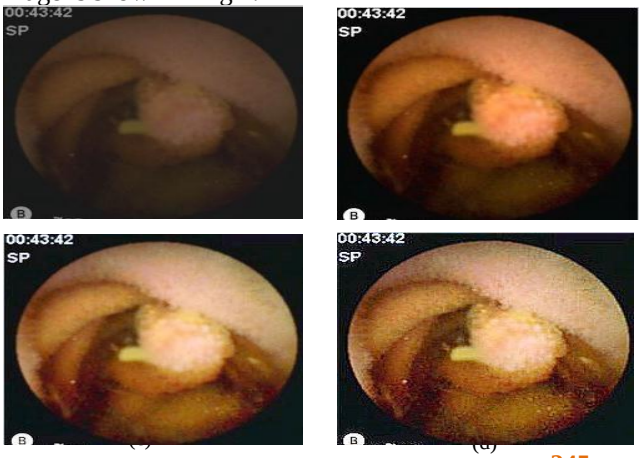

Fig 2: (a) Low Contrast Image, (b) After contrast stretching, (c) After CLAHE, (d) After unsharp filtering

Table 1: Quality metric parameter of different methods

Quality metric parameter	Proposed Method
SSIM	0.98
PSNR	32.84
MSE	33.75

6. CONCLUSION

In this paper, for improving the quality of WCE images, contrast stretching is first used to adjust the contrast of the input image. Further Contrast Limited Adaptive Histogram Equalization (CLAHE) is employed. Then, finally unsharp filtering is done to sharp the image. This method can highly improve the quality of the image. The proposed method can be used to enhance low contrast or poor quality medical images and that is helpful for diagnosis purposes.

REFERENCES

[1]. Dileep.MD and A.Sreenivasa Murthy, –*A Comparison between different Color Image Contrast Enhancement Algorithms*‖, IEEE, Proceedings of ICETECT 2011, pp 708-712.

[2]. Chen, Soong-Der and Ramli, Abd. Rahman, –*Minimum Mean Brightness Error Bi-Histogram Equalization in Contrast Enhancement*‖, IEEE Transactions on Consumer Electronics, Vol. 49, No. 4, 2003, pp. 1310-1319.

[3]. R.Gonzalez & R.Wood , Digital Image Processing,3rd .ed. Englewood Cliffs, NJ: Prentice Hall, 2007

[4]. Vijay A. Kotkar Sanjay.S Gharde, ‟ *Review of various image contrast enhancement techniques*‖ in Image Processing, International Journal of Innovative Research in Science, Engineering and Technology Vol. 2, Issue 7, July 2013.

[5]. K. Karthikeyan and C. Chandrasekar, –*Wavelet-based Image Enhancement Techniques for Improving Visual Quality of Ultrasonic Images*‖, International Journal of Computer Applications, p.p. 0975–8887, Vol. 39, No.17, Feb. 2012.

[6]. Menotti D, Najman L, Facon J and Araujo, Present a –*Multi-Histogram Equalization Methods for Contrast Enhancement and Brightness Preserving*‖, in IEEE Transactions on Consumer Electronics, Vol. 53, No. 3, pp.1186-1194, 2007.

[7]. Herrerías, J. M., Mascarenhas, M., 2007, Atlas of Capsule Endoscopy, Sulime Diseño deSoluciones, Sevilla.

[8]. G. Iddan, G. Meron, A. Glukhovsky, and P. Swain, –*Wireless capsule endoscopy*,‖ Nature, vol. 405, p. 417, 2000.

[9]. D. D. Adler and C. J. Gostout, –*Wireless capsule endoscopy*,‖ Hospital Physician, pp. 14-22, May 2003.

[10]. B. Li, and M.Q.H. Meng, –*Wireless capsule endoscopy images enhancement using contrast driven forward and backward anisotropic diffusion*‖, IEEE International Conference Image Processing, pp.437-440, 2007.

[11]. K. Sandrasegaran, D.D.T. Maglinte, S.G. Jennings, and M.V.Chiorean, –*Capsule endoscopy and imaging tests in the elective investigation of small bowel disease*,‖ Clinical Radiology, vol. 63, pp. 712-723, 2008.

[12]. F. Arguellas-Arias, A. Caunedo, J. Romero, A. Sanchez, M. Rodriguez-Tellez, F.J. Pellicer, F.Arguelles-Martin, and J.M.Herrerias, –*The value of capsule endoscopy in pediatric patients with a suspicion of Crohn's disease*,‖ Endoscopy, vol. 36, pp. 869–873, 2004.

[13]. Manvi, Rajdeep Singh Chauhan, Manpreet Singh, –*Image contrast enhancement using histogram equilization*,‖ International Journal of Computing & Business Research, ISSN. 2229-6166, Proceedings of _I-Society 2012' at GKU, Talwandi Sabo Bathinda (Punjab)

[14]. K. P Indira and R. Rani Hemamalini, –*A Method for Contrast Correction and Enhancement For Medical Images using Wavelet Fusion*‖, In proceedings of International Conference on Computing and Control Engineering(ICCCE), 2012.

[15]. R.Senthilkumar and Dr.M.Senthilmurugan –*triad histogram to enhance chest x-ray image*‖, International Journal of Advanced Research in Computer and Communication Engineering, Vol.3, Issue 11, November 2014.

[16]. M. Sundaram, K. Ramar, N. Arumugam and G. Prabin, –*Histogram Modified Local Contrast Enhancement for Mammogram Images*‖, International Journal of Biomedical Engineering and Technology, Vol. 9, No. 1, pp.60-71, 2012.