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Novel Image Enhance Method Based on Blind Deconvolution and Contrast Limited Adaptive Histogram Equalization for Wireless Capsule Endoscopy

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Abstract— **Wireless capsule endoscopy is utilized extensively to visualize the small intestine. Wireless capsule is regularly prescribed to distinguish ulcer, bleeding, cancer etc. This procedure does not affect the patients during the diagnosis, henceforth it has been presently acclaimed among the doctors and patients. The quality of WCE images is very important for diagnosis. During a diagnosis the system generates multiple images of the small intestine; however it is not sufficient for the doctors to analyze the result. In spite of this need, require an expertise computerized system to eradicate the difficulties in the diagnosis. In the existing method of examination the most spotted challenges are exceptionally low contrast image and the image generated on this process are texture based. On this research develop a Novel Image Enhance Method based on Blind Deconvolution with Contrast Limited Adaptive Histogram Equalization (BD-CLAHE) method to improve the image quality.**

Keywords— Wireless Capsule Endoscopy (WCE), Contrast Enhancement, Medical Image Processing, Blind Deconvolution, Contrast Limited Adaptive Histogram Equalization.

I. INTRODUCTION

As per the diagnostic studies colorectal cancer is in the third place of cancer. According to the estimation of cancer society of India 2016, 1327000 colorectal cancer victims were found. The colorectal polyp is the primary stage of colorectal cancer. When left untreated it develops into cancer. So, to identify polyps and treat it before it develops into cancer, an easy method was needed for the doctors. Endoscopy is a good technique to detect colorectal cancer earlier.

There are different types of endoscopy viz. colonoscopy, bronchoscopy, and gastroscopy and push endoscopy. But most types of endoscopy have limited capability to examine the small intestine. To address this problem a device known as wireless endoscopy was manufactured. This device possesses the capability to transfer video and image by wireless technology. This method was introduced in 2000 A.D [8]. Wireless capsule endoscopy is a revolutionary breakthrough in the medical field [1]. It allows painless observation of the small intestine. Fig. 1 shows examples of abnormal images of WCE. However it has certain limitations. First the battery capacity of the wireless capsule endoscopy is limited. So the image captured is low-focused image and so the image is blurred [2]. Hence image enhancement is indispensable for the doctor to identify the abnormality of the small intestine. Moreover this preprocessing is used to enhance the accuracy of the forthcoming modules like segmentation and classification.

A. Image Enhancement

Image enhancement performs very important role in wireless capsule endoscopy. The main aim of WCE image enhancement is to increase the visibility of dark regions and decrease the brightness of highly brightened images from which the problems in GI tract can be diagnosed effectively. There are many enhancement techniques such as Narrow Band Imaging (NBI), I-scan and fuzzy Intelligent Chromo Endoscopy (FICE) used for improving the quality of images [3]. Filters are used to improve the low and the high frequency components. Some techniques are used to increase the brightness, contrast and reduce the noise of WCE images such as Retinex Algorithm [4], [5] Histogram Equalization and Color reproduction.

(a) Angiodysplasia

(b) Ascaris Lumbricoides

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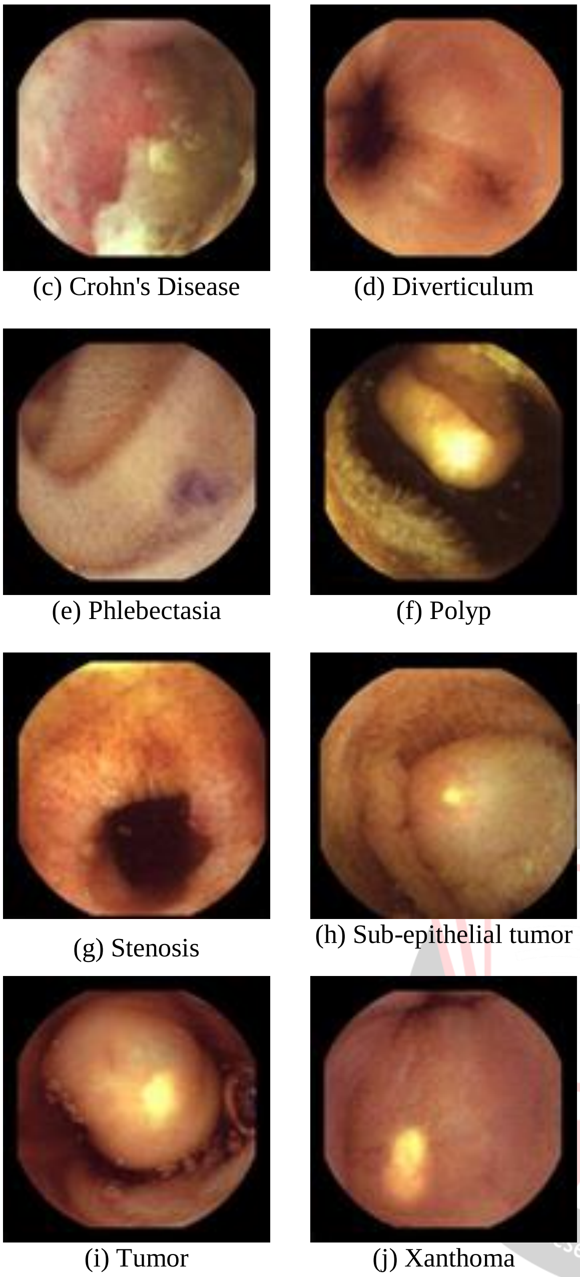

Fig. 1. Snapshots of the WCE Images.

B. Working Process of Wireless capsule endoscopy

The patient should swallow the capsule. As the capsule is wireless no wire is connected there with. So it will be comfortable and painless for the patient. Moreover this method needs no sedation. Consequently it will be of great avail to the old as well as weak people. The face of the wireless endoscope is covered with an optical dome. It has a light emitting diode. Moreover a CMOS is fitted with the capsule [3]. The endoscopy takes more than 50,000 images in the observation of the patient. These images are stored in a storage device by wireless transformation method. Fig 2 shows the different steps of the WCE imaging.

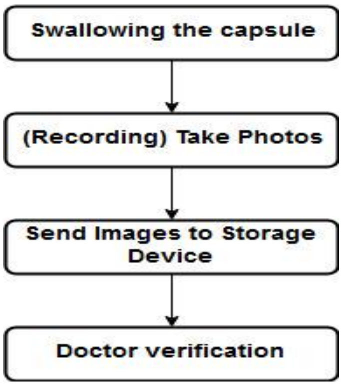

Fig 2. Steps of operation in WCE

The remainder of this paper is organized as follows. The next section presents Literature Review. Section III illustrates the proposed Novel Image Enhance Method based on Blind Deconvolution and Contrast Limited Adaptive Histogram Equalization, and the technique details of the proposed enhancement method. The results of the experiments conducted and presented in Section IV. Finally, the paper is concluded in Section V.

II. LITERATURE REVIEW

In recent years, researchers investigated the problem of detection of polyps, bleeding, ulcer and other abnormalities in Wireless Capsule Endoscopy images. Abdolrahman Attar, Xiang Xie, Chun Zhang, Zhihua Wang and Shigang Yue presented Wireless Micro-Ball Endoscopic Image Enhancement Using Histogram Information [6]. The method consist of three modules; Color space transformation, edge preserving mask formation, and histogram information correction. A color space is a method is used for create and visualize the endoscopy image. Following color spaces are extracted: RGB, CIE Lab, YCbCr, and HSV. In [6], they perform a nonlinear filter and Median Filter to reduce the noise. Apply the one dimension Gaussian filter for and histogram information correction.

Cal Selka, Stephane , Nicolau, Vincent Agnus and Abdel Bessaid proposed Evaluation of Endoscopic Image Enhancement for Feature Tracking: A New Validation Framework. In [7] they propose two real-time pre-processes methods based on image filtering, to improve feature tracking robustness and thus reduce outlier percentage. In order to improve detection and tracking algorithms on endoscopic images they present novel tracking system using Forward-Backward Tracking Based on Even-odd Frames. They claimed that their proposed work significantly increase the tracking performance.

Jungle Chi-Hsiang Wu, Guo-Shiang Lin, Hsiao-Ting Hsu, You-Peng Liao , and Kai-Che Liu implemented a quality enhancement scheme for endoscopic images. They [8] integrates a retinex algorithm and a pseudo-HDR synthesis process to achieve enhanced images. The integration is composed of three parts: MSR-G, brightness diversity, and

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HDR synthesis. The author claimed that both advantages of MSR and HDR, and hence is able to enhance the most image details and keep the overall visual quality good.

Hiroyuki Okuhata,, Hajime Nakamura, Shinsuke Hara, Hiroshi Tsutsui, and Takao Onoye proposed Application of the Real-Time Retinex Image Enhancement for Endoscopic Images. They [9] used Retinex image enhancement technique to improve video images obtained from gastric endoscopy. The author said that the proposed allows real-time processing with low computational complexity.

Mohammad Shamim Imtiaz, Tareq Hasan Khan and Khan Wahid introduced New Color Image Enhancement Method for Endoscopic Images [10]. This method comprises by two interrelated steps: Image enhancement and Color reproduction. This method RGB endoscopic images are enhanced using FICE algorithm and the color reproduction is applied by transferring chrominance map from a source image to the enhanced gray scale spectral image in the process of matching luminance and texture information.

Table 1 Comparisons of existing methods

Technique used for image enhancement	**Local/ global**	**Image Component**	**Enhancement**	**Disadvantages**
[8] Retinex	Global	Luminance/ Reflectance	Contrast/Color	Graying effect for gray-world assumption violation.
[9] Retinex	Global	Luminance	Contrast	Graying effect for gray-world assumption violation.
[10] Color reproduction	Global	Luminance/ Reflectance	Contrast/Color	Computational complexity
[6] HE	Global	Luminance/ Reflectance	Contrast/Color	Noise amplification

III. PROPOSED METHODOLOGY

In this section introduce new algorithm for improving quality in WCE images. These images suffer low contrast and existence noise hence removing noise at first then contrast enhancement. The CLAHE methods have produced good results on medical images. Therefore, the proposed image enhancement for WCE is based on CLAHE. Proposed method contains two main modules: Deblurring and contrast enhancement.

A. Deblurring

The process flow block diagram shown in fig3 gives the sequence of operations of the proposed system. The individual blocks are expanded with its process in the following sections.

Input Image

In this research the low contrast and blurred image taken from the WCE is used as the input image. Proposed system the WCE images collected patients of 40-60 years of KIMS is taken for this study. This new algorithm has been designed so as to process different types of WCE images.

UnSharp Filter and Deconvolution

Unsharp masking (USM) is an image sharpening technique. This is commonly available at digital image processing software's. First the given input image is preprocessed using the unsharp filter. As the given image is a colored one a separate mask has been designed for RGB component. Secondly, using the simple PSF(Point Spread Function) function the deconvolution process is carried out. Thirdly, in order to get edges from blurred image the restoration is carried out. Setting the gradient energy as the weight function the final restoration process is carried out and the blind deconvolution is carried out to get the deblurred image.

Deblurring

In this proposed contrast enhance method Blind Deconvolution algorithm along with unsharp mask filter is used to restore blurred and noisy image. Blind Deconvolution algorithm restores the image and the PSF altogether.

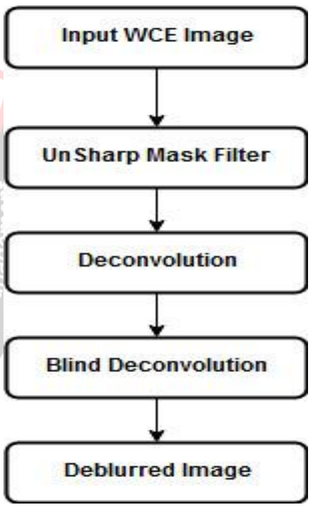

Fig 3 the process flow block diagram of deblurring.

Algorithm

Step1: Read WCE Image.

Step2: Simulate the input image that could be blurred.

Step3: The Gaussian filter then represents a point-spread function, PSF.

Step 4: Restore the Blurred WCE Image Using PSFs of Various Sizes.

Step5: Analyzing the Restored PSF: In the true PSF, a Gaussian filter, the maximum values are at the center and diminish at the borders.

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Step6: Improving the Restoration: The sharp intensity contrast in the image and along the image borders. The algorithm weights each pixel according to the WEIGHT array while restoring the image and the PSF.

Step7: Deblurred Image.

Contrast limited adaptive histogram equalization

The Contrast Limited Adaptive Histogram Equalization (CLAHE) is the modified technique of Adaptive Histogram Equalization (AHE). In this CLAHE method the enhancement function is applied in all neighbor pixels and the transformation function is derived. CLAHE differ from AHE in that the contrast is limited. The steps of the proposed algorithm explained bellow.

Algorithm Steps:

Step 1: Divide the each input image into a number of non-overlapping contextual regions of equal size of the 8x8 blocks, each of which corresponds to the neighborhood of 64 pixels.

Step 2: Calculate the intensity histogram of each contextual regions.

Step 3: Set the clip limits for clipping the histograms, (for example c=0.002). The clip limit is a threshold parameter for effectively altering the contrast of the image. Higher clip limits increases the contrast of local image regions thus it must be set to minimum optimal value.

Step 4: Modified the each histogram by the selecting a transformation functions.

Step 5: Each histogram is transformed in such a way that its height did not exceed the selected clip limit.

The mathematical expression for transformed gray levels for standard CLAHE method with Uniform Distribution can be given as.

$$g = [g_{max} - g_{min}] * P(f) + g_{min} \qquad (1)$$

Where g_{max} = Maximum pixel value
g_{min} = Minimum pixel value
g is the computed pixel value
$P(f)$=CPD (Cumulative probability distribution)

For exponential distribution gray level can be adapted as

$$g = g_{min} - \left(\frac{1}{\alpha}\right) * \ln[1 - P(f)] \qquad (2(a))$$

Where is the clip parameter? CLAHE method operates on small regions in the image, called "tiles", rather than the entire image. Each tile's contrast is enhanced, so that the histogram of the output region approximately matches the histogram specified by the Distribution type. The CDF of Rayleigh distribution is given as;

$$y = P(f(x \backslash b)) = \int_0^x \frac{x}{b^2} e^{\left(\frac{-x^2}{2b^2}\right)} \qquad (2(b))$$

Step 6: The neighboring tiles were combined using bilinear interpolation and the image grayscale values were altered according to the modified histograms.

IV. EXPREMENTAL ANALYSIS

To evaluate the proposed image enhancement method several experiments are conducted. The WCE images are taken from the Noorul Islam Medical Society hospital. The images are of the patients of 40-60 age range and the size of the image is 480×480. Since the images taken is RGB images they can be directly enhanced. The results obtain from proposed method is compared with the Retinex method, Color reproduction and Histogram Equalization method that exist already.

Fig 6 gives set of experimental results and also it contain the original images. Our proposed method gives highly visible images. The dark regions are clearly visualized. We have shown it in fig 4 D. The image provided by the Retinex algorithm has been shown in fig 4b, 5b and 6b. Though it produce good result but still it is not so good as the one proposed. In fig 6 jejunum erosion disease has been taken for our experiment. The retinex algorithm produces certain changes still the dark regions are not visible but our new method yields excellent result. It has been shown in fig 4d,5d and 6d.

V. CONCLUSION

This paper introduces a new method for improving the quality of WCE images called Novel Image Enhance Method Based on Blind Deconvolution and Contrast Limited Adaptive Histogram Equalization (BD-CLAHE). Practical aspect of this work is that the deblurring and Contrast Enhancement (BD-CLAHE) method can directly impact the quality of WCE diagnostic images. The experimental results demonstrate that our proposed method can reveal details of poor illumination endoscopic images effectively and has outstanding performance compared with the state-of-art methods. Future study will focus on reducing the computational complexity of the proposed approach and automatic segmentation based on the enhanced images.

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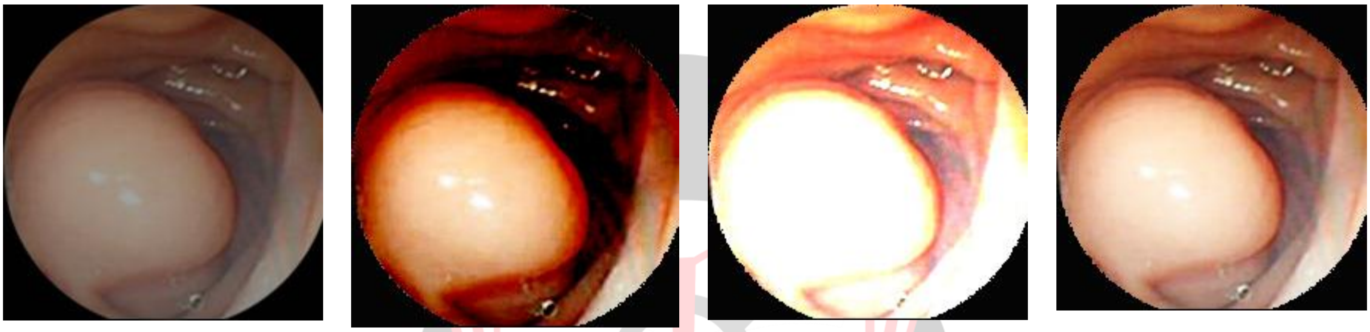
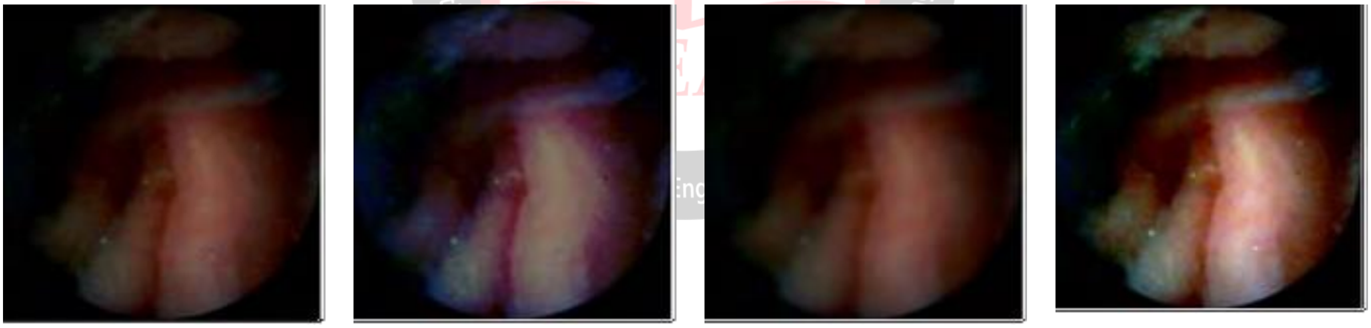


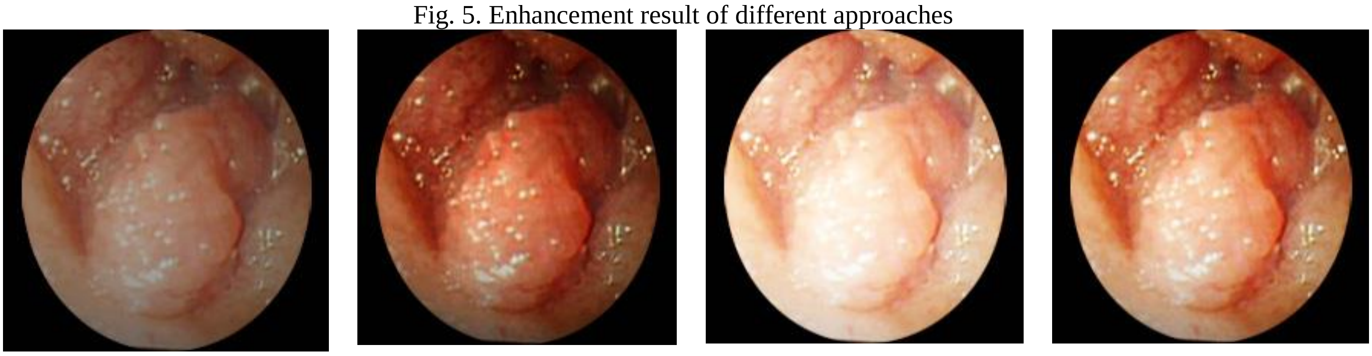
(a) Original image (b) Retinex (c) Color reproduction (d) BD-CLAHE

Fig. 4. Enhancement result of different approaches



(a) Original image b) Retinex (c) Color reproduction (d) BD-CLAHE

Fig. 5. Enhancement result of different approaches



(a) Original image b) Retinex (c) Color reproduction (d) BD-CLAHE

Fig. 6. Experimental results of different approaches

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