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RESEARCH ARTICLE

Enhancing the Images from Endoscopic Camera Using TV-Image Decomposition

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Abstract - Endoscope is an instrument used to examine the interior of a hollow organ or cavity of the body. Unlike most other medical imaging devices, endoscopes are inserted directly into the organ. During endoscopic operations the surgeon usually works without direct visual contact with the operation area which is displayed on a monitor. So we need to improve the quality of images for diagnosis of any tumors or diseases inside our human body. The input images from the endoscopy camera are digital and are received at the computer USB port. The aim of this paper was to introduce a new approach for histogram equalisation which involves the application of the Total Variation (TV) model to extract cartoon-texture component from the image. The undesired artifacts such as intensity saturation and over-enhancement that are overcome by this approach during the image contrast enhancement process. The experimental results shoes that the proposed method using combination of TV Texture Enhanced - Histogram equalisation (TE-HE) with Dark Channel Prior (DCP) strategy is an effective approach for contrast enhancement and also this algorithm able to outperform other Histogram equalization based methods when applied to image corrupted by noise. Thus this paper shows the enhanced and the original image at the same time so that doctors can clearly see the results and correctly predict the diseases easily.

Keywords: Contrast enhancement, TV imaged composition, histogram, DCP.

I. INTRODUCTION

The principal objective of image enhancement is to process a given image so that the result is more suitable than the original image. It sharpens image features such as edges, boundaries, or contrast to make a graphic display more helpful for display and analysis .The enhancement doesn't increase the inherent information content of the data, but it increases the dynamic range of the chosen features so that they can be detected easily. Basically image enhancement means improving the contrast of the image and reducing the noise. Image enhancement methods can be based on either spatial or frequency domain techniques. Spatial domain techniques are performed to the image plane itself and they are based on direct manipulation of pixels in an image. The frequency domain enhancement method can enhance an image by convoluting the image with a linear, position invariant operator. The 2D convolution is performed in frequency domain with Discrete Fourier Transform (DFT) on every picture elements. The Adaptive Histogram Equalization (AHE) is used to improve the contrast in images [1].The disadvantages of this approach are it will amplify the noiseand fails to preserve the brightness with respect to the input image. Automatic contrast enhancement (ACE) by global histogram modification is a technique of image enhancement for visual inspection [2]. The disadvantage of this method is that it will over enhance the image. The above disadvantages are overcome by the proposed method.

II.OVERVIEW OF THE PROPOSEDCONTRAST ENHANCEMENT ALGORITHM

The proposed contrast enhancement approach involves a multi-step algorithm that applies the TV [3] – [7] model to obtain the cartoon-texture decomposition of the input image. An overview of the proposed contrast enhancement algorithm is depicted in Fig 1. The input image is captured from endoscopic camera is digital. In the pre-processing step the input image is passed through notch filter to remove 50 hertz noise from the image. A notch filter is a band-stop filter with a narrow stop band. They are more often used for noise reduction or elimination of undesirable artefacts in a signal. The figure 1 shows that after the extraction of the cartoon-texture image components from the image, contrast enhancement is achieved by applying a non-linear histogram warping process. The figure 2 shows the overall setup and components used to capture the image.

a).TV Cartoon-Texture Decomposition: The main objective of this process is to extract the texture component, as this contains the meaningful information in the input image and help us to rejects the undesirable intensity transitions. Total variation (TV) models have been widely employed for data denoising, face recognition, texture enhancement and blind deconvolution. Using this variational approach, the input image can be decomposed as shown below in equation (1) and (2)

$$I = c + t \tag{1}$$

$$t = I - c \tag{2}$$

where I denotes the original image, c denotes the cartoon and t denotes texture component. The cartoon image c, which contains the which contains the de-textured components from the input image I, can be determined by minimising the following expression (3)

$$\min \int |\nabla c| + \lambda \|I - c\| \, d\Omega \tag{3}$$

where denotes the image domain and denotes the Lagrange multiplier which is inversely proportional to the strength of the data smoothing process.

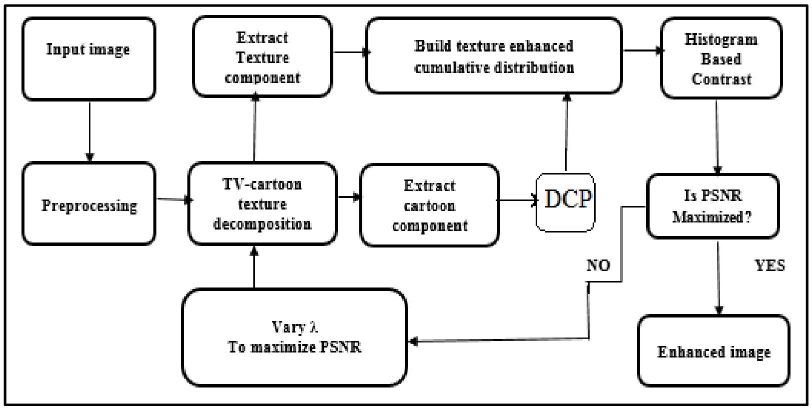


Figure. 1 Overview of the proposed contrast enhancement algorithm.

Figure. 2 Endoscopic camera connected to the laptop via USB port.

b)Procedure To Extract Cartoon Component: The procedure described below help us to extract the cartoon component from the test image. The bilateral filter [4] is applied first to input image which is a non-linear technique that can blur an image while respecting strong edges. It depends only on two parameters that indicate the size and contrast of the features to preserve. Once cartoon component is extracted, the texture component from the image can be obtained by subtracting original test image from the cartoon component for that image.Cartoon image is applied to DCP strategy [8].After that histogram transformation is performed and the PSNR value is calculated. The procedure to extract the cartoon component is described below in flowchart 1

C. Texture-Enhanced Histogram Equalisation: After the extraction of cartoon-texture component, the next step of the proposed algorithm involves the calculation of the histogram transformation that is applied for contrast enhancement. The aim is to avoid the intensity saturation and over-enhancement effects that are introduced by the standard histogram equalization process. The idea behind this method is to implement a local intensity mapping process that modify the shape of the histogram. The first step is to identify the pixels that are associated with strong textures after the application of the cartoon texture decomposition [3].The binary texture map is obtained by applying the equation (4).

$$t_{ij}^{b} = \begin{cases} 1, & |I_{ij} - c_{ij}| > p \\ 0, & \text{otherwise} \end{cases}, \; p \in R^{+} \tag{4}$$

Where t^b is the binary texture map and p= 1.0.After the identification of the texture pixels that are associated with the input image, the next step is the evaluation of the neighbourhood around each texture pixel. After this the aim is to identify the extreme intensity values within the neighbourhood that will be used to alter the intensity distribution H_c that is calculated from the cartoon component. The calculation of the histogram H_c which is shown in equations (5) to (7).

$$H_c = \bigcup_{p \;\; M} h_c(p) \tag{5}$$

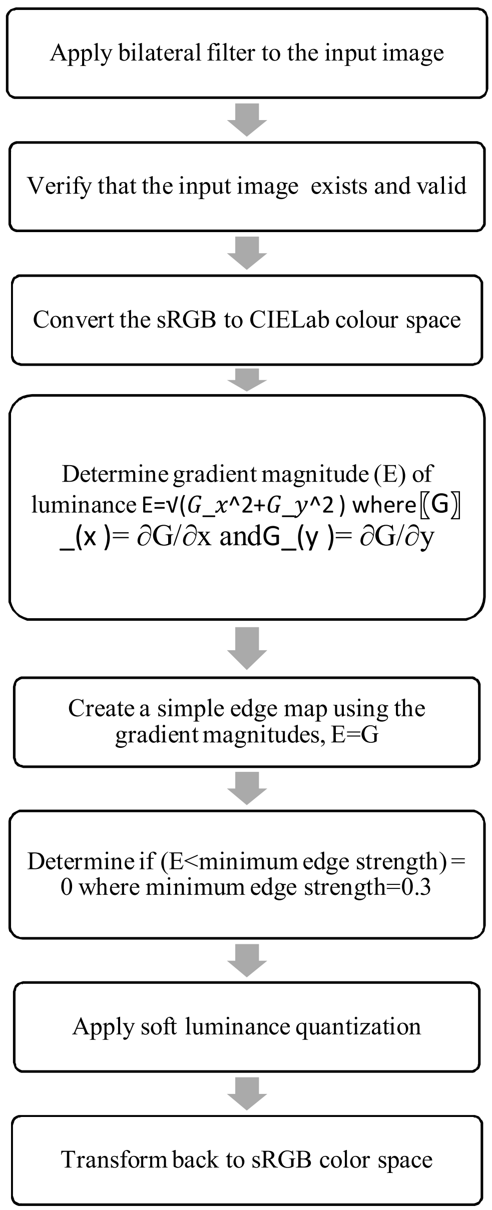
$$h_C(p)= \int_{(i,j)\ \ \Omega}\delta(c_{ij},p)\,d\Omega \tag{6}$$

$$\delta(c_{ij},p) = \begin{cases} 1, c_{ij} = p \\ 0, c_{ij} \neq p \end{cases} \tag{7}$$

where The procedure for Texture–enhanced histogram transformation are described in the following steps:

Step 1: For every pixel (i,j) belongs to image domain and if texture pixel equal to one.
Step 2: Then construct 3×3 neighbourhood around each texture pixel.
Step 3: Calculate lowest and highest intensity values.
Step 4: If those intensity values lies in p then increase the intensity distribution by one.
Step 5: Repeat the above steps for all pixels in the test
The entropy is calculated using the below expression (8):

$$E(H_n) = -\sum_{s\in M} H_n(s)\log_2(H_n(s)) \sum_{s\in M} H_n(s) = 1 \tag{8}$$



Flowchart 1: Describes the procedure to extract the cartoon component from the image

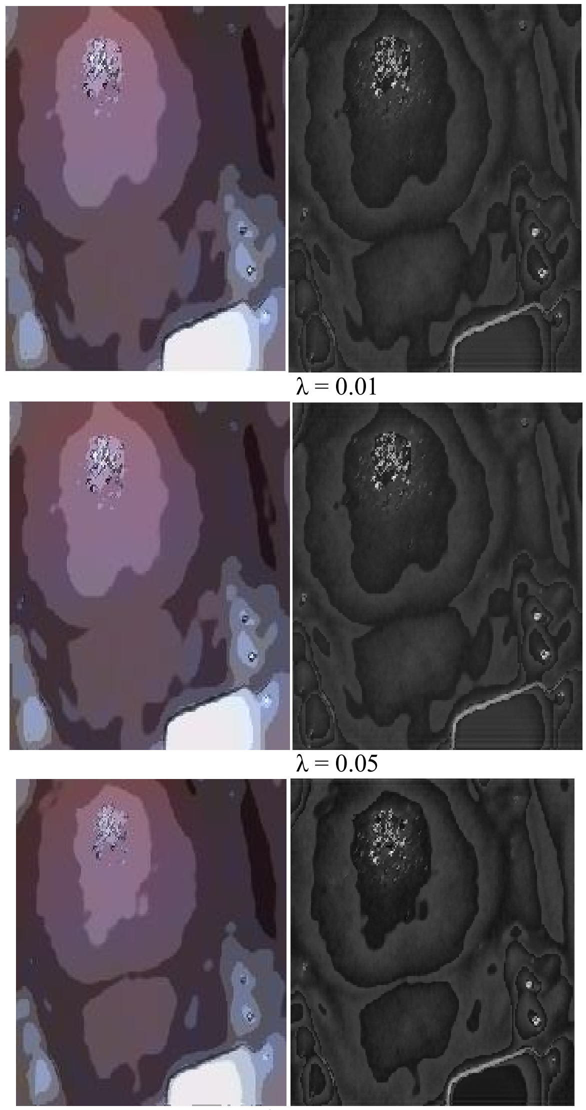


Figure. 3 Cartoon-texture component for different values of the parameter λ.
(Left: Cartoon images. Right: Texture images)

Where E is the entropy measure, $H_n$is the normalised version of the distribution [4]. The entropy is a measure of the average information present in the image, our objective is to maximise the expression of the entropy $E(.)$.Since the accurate decomposition of the input image into cartoon and texture components plays the central role in the proposed CE, the parameter λ should be conducted with the aim of maximising the information content. The TV means how much the nearby pixels vary with respect to intensity The TV based image decomposition is controlled by the parameter λ which is inversely proportional to the level of smoothing in the cartoon in the contrast enhanced image.Vary this parameter until the entropy is maximized.

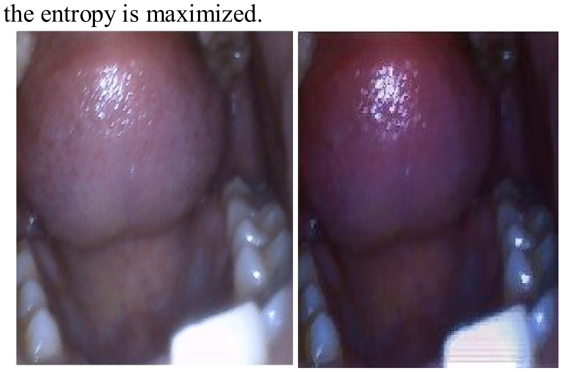


Figure.4 (a) Input image and (b) Enhanced image

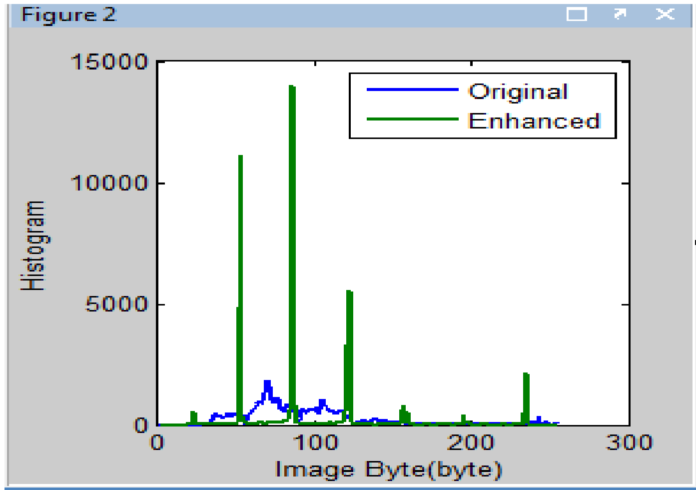


Figure.5 Histogram plot for original image (Blue line) and enhanced image (Green line)
(x-axis represents gray level values and y-axis represents number of occurrence of those values)


Figure.6 (a) Input Anthill image and (b) Enhanced Anthill image

III.EXPERIMENTAL RESULTS

The Fig. 3 shows the cartoon-texture decomposition for various values of λ. Figure 4 shows the original and enhanced image for mouth image captured using the endoscopic camera .Fig. 5 shows the histogram plot for the original and enhanced image. Fig. 6 shows the test image captured using that camera. Table 1 show the PSNR and entropy values for test images.

Table.1 PSNR and Entropy value for test Images

Input image	PSNR	Entropy
Mouth image	+37.74 dB	6.8464
Anthill image	+34.06 dB	7.2639

IV.CONCLUSION

The major aim of this paper was to introduce the new approach which involves the use TV model to obtain cartoon-texture decomposition approach for contrast enhancement without over enhancing the image. This method also avoids undesired artifacts such as intensity saturation effect. It will help the doctors to predict the various diseases at very early stage and save the life of people .If we identify diseases like tumors it can be curable nowadays so quality of image must be enhanced.

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