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Implementation of Universal Image Quality Index (UIQI) on Halftoned Images

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Abstract - Halftoning, the transformation from grayscale images into dual-tone binary images. An image having several bits for brightness levels is converted into a binary image consisting of black and white dots which looks similar to an input image. Halftoning is the process of converting continuous-tone images into strictly black and white images such that, when viewed by the human visual system, the pattern creates an illusion of being a continuous shade of gray.. The quality of a halftone image cannot be judge before it is reproduced. In this paper, Universal Image Quality Index (UIQI) is implemented as performance parameter on Halftoned images which depends on luminance, contrast, covariance and structural comparison attributes.

Key Words: Binary Image, Contrast, Error Diffusion, Halftoning, uminance, Structural Comparison, Universal Image Quality Index(UIQI)

1.INTRODUCTION

The modern world is constantly exposed to different images produced by magazines, books, posters, newspapers, televisions, etc. As an integral part of daily life, images have evolved into many valuable commercial endeavors. Printing industry is one of them. Recent years have witnessed enormous economic powers generated by printing industry businesses due to the increasing demand for high quality printing high fidelity gray scale images such as photographs, art work, design renderings, magazine layouts, etc. "Halftoning ", is a major technology used in printing images. In general terms, it is a process of creating a binary approximation to a sampled gray scale image that creates the illusion of a continuous tone image.

Originally, halftoning was performed mechanically by printers that printed images through a screen with a grid of holes. During the printing process, ink passed through the holes in the screen, creating dots on the paper. For monochrome images, only one pass was needed to create an image. For multicolor images, several passes or "screens" were required. Today's printers are more advanced and typically do not contain physical

screens. Instead, the halftone images are generated by a computer and the resulting image is printed onto the paper.

An 8-bit monochrome image allows 256 distinct gray levels. Modern computer monitors generally support the display of such images, however some other rendering technologies allow for much fewer gray levels. At the far end of the spectrum are devices, such as printers, that can only display two levels, black or white, for a monochrome image. This will introduce a useful area of image processing called halftoning, which is the conversion of a grayscale image into a binary image. Halftoning is a representation technique to transform the original continuous tone digital image into a binary image only of 1's and 0's consisting. The value 1 means to fire a dot in the current position and 0 means to keep the corresponding position empty. Since the human eyes have the low pass spatial-frequency prosperity, human eyes perceive patches of black and white marks as some kind of average grey when viewed from sufficiently far away. Our eyes cannot distinguish the dots patterns if they are small enough. Instead, our eyes integrate the black dots and the non-printed areas as varying shades of gray. When viewed from a distance, the dots blur together, creating the illusion of continuous lines and shapes. Zooming in a part of the halftoning image, we can see that the image is actually structured by a certain strategy of distributed black dots.

The quality of a halftone image depends largely on the its resolution. A halftone with a high resolution (measured in LPI), will have greater detail than a halftone with a low resolution. While the goal of halftoning is typically to create a realistic image, sometimes low resolutions are used for an artistic effect. The key in this application is to exploit properties of the human visual system to give the impression of a continuous tone image even though only two levels are present in the rendering. Halftoning is required in several electronic applications such as facsimile (FAX), electronic scanning and copying, and laser and inkjet printing.

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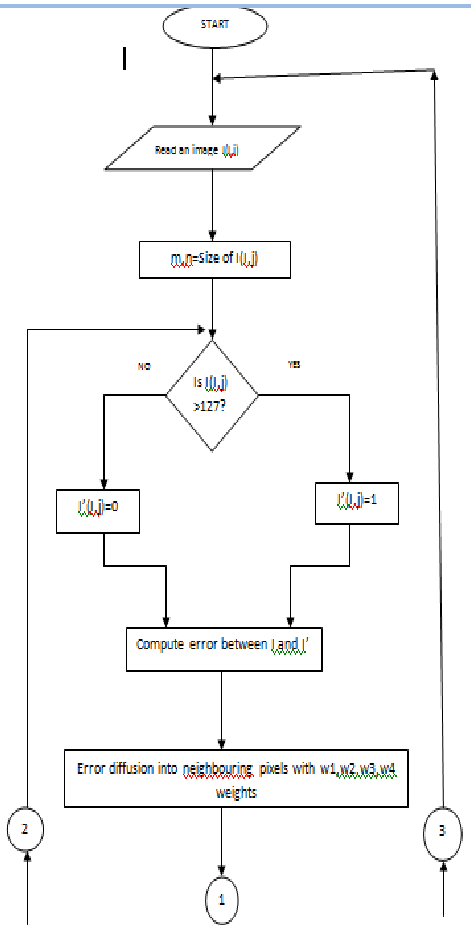
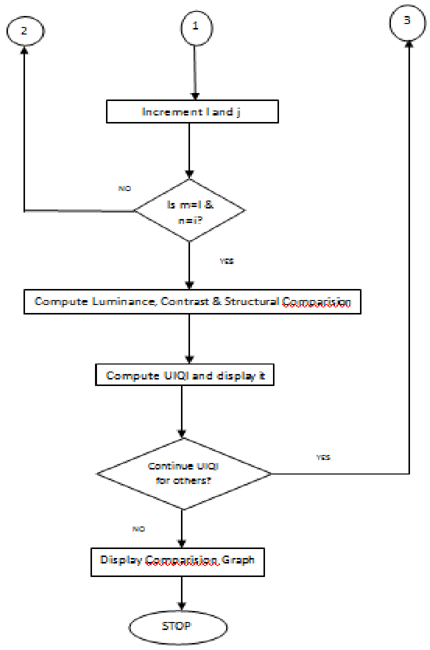
2. Algorithm

1. Read an input image 'I'
2. For each pixel of I(i,j) set
3. $I'(i,j) = \begin{cases} 1 & I(i,j) \geq 127 \\ 0 & \text{elsewhere} \end{cases}$

4. Compute error in I(i,j) and I'(i,j)
5. Diffuse this error to the neighboring pixels with error diffusion weight
   Eg : Error in (i,j) pixel is weighted by W1 and added to the neighborhood pixel (i+1,j) and at the same time error is weighted by W2 (W2<W1) and added to the neighborhood at (i+1,j+1) and so on. Here the values of the weights are 1/48, 3/48, 5/48 and 7/48.
6. Repeat step 3 to step 4 until all the pixels have been processed.
7. Compute Luminance, Contrast, Structural Comparison.
8. Compute UIQI and Display it.
9. Repeat the steps 1 to 9 on every input image.
10. Display computed UIQI values in a bar graph

3. Flow Chart





4. System Design

The following figure shows the block diagram:

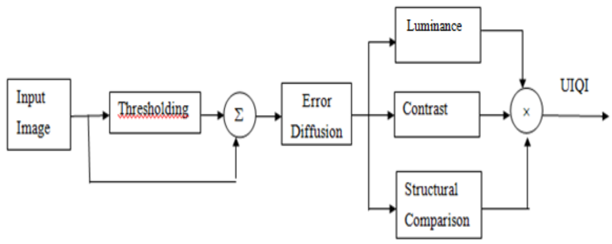


Fig 1: Block Diagram

The input image will be bmp, jpg, tif or any other color image. Here color image is given as the input to this project. Over that image thresholding operation is carried over on every pixel. The image such obtained holds different depth in every pixel. The error between input and threshold image will be calculated and such obtained error will be diffused into the neighborhood pixels so that output image is looks very much even.

If I is an input image then the pixel I(i,j) will be compared with 255 and as shown a below:

$$I'(i,j) = \begin{cases} 1 & I(i,j) > 127 \\ 0 & \text{Otherwise} \end{cases} \quad \text{-----(1)}$$

In the above equation I' indicates threshold image which is not even..

			7/48	5/48
3/48	5/48	7/48	5/48	3/48
1/48	3/48	5/48	3/48	1/48

Fig 2: Error Diffusion Weight Matrix

Hence between I and I' error will be calculated for every pixel.Error will be diffused using the 1/48, 3/48, 5/48 and 7/48 weights into neighbourhood pixels.See the following fig 2

4.1 Universal Image Quality Index (UIQI):

Universal image quality index is easy to calculate and applicable to various image processing applications. It is a mathematically defined measure which is attractive because of two reasons. First, they are easy to calculate and usually have low computational complexity. Second they are independent of viewing conditions and individual observers. Although it is believed that the viewing conditions play important roles in human perception of image quality, they are, in most cases not fixed and specific data is generally unavailable to the image analysis system. If there are N different viewing conditions, a viewing condition-dependent method will generate N different measurement results that are inconvenient to use. In addition, it becomes the user's responsibilities to measure the viewing conditions and to calculate and input the condition parameters to the measurement systems. By contrast, a viewing condition-independent measure delivers a single quality value that gives a general idea of how good the image is.UIQI is defined with the following equation:

$$UIQI = \frac{\sigma_{xy}}{\sigma_x \sigma_y} \frac{2\,\bar{x}\,\bar{y}}{\bar{x}^2 + \bar{y}^2} \frac{2\sigma_x \sigma_y}{\sigma_x^2 + \sigma_y^2} --- (2)$$

In eq(2), the first term defines the degree of correlation between input and output images with dynamic range between [-1,1], the second term measures how close the luminance is between x and y range is [0,1] and the third term measures how similar the contrasts of the input and output images.

The universality in the image quality index means that the approach does not depend on the image being tested, the viewing conditions or the individual observers. More importantly, it must be applicable to various image processing and provide meaningful comparison across different types of image distortions. UIQI attempts to replace the currently and widely used PSNR and MSE techniques.

5. Experimental Results

Fig 1 shows various inputs which are considered here:

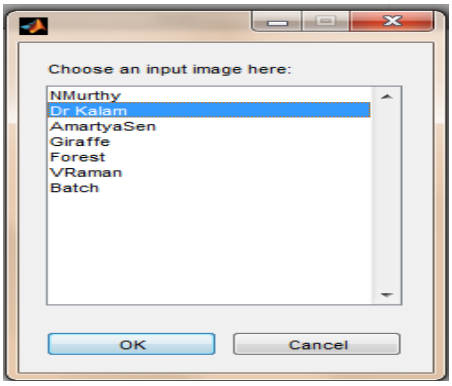


Fig 3 : Shows various inputs

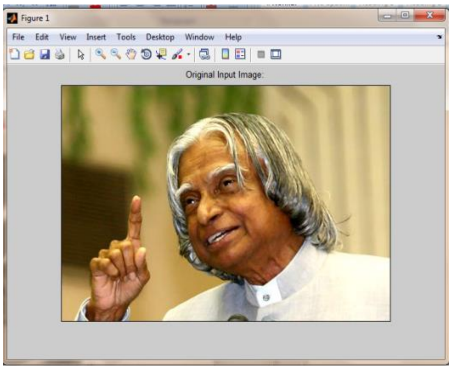


Fig5: Shows Gray Image

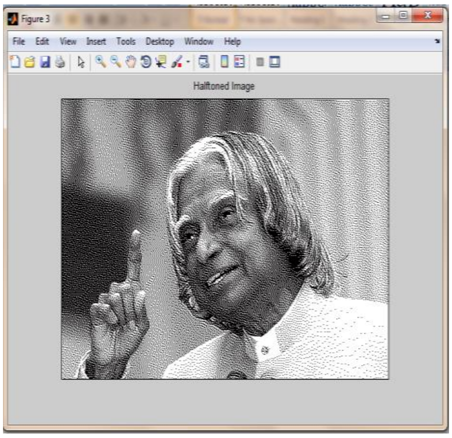


Fig 6: Shows the Holftoned Image

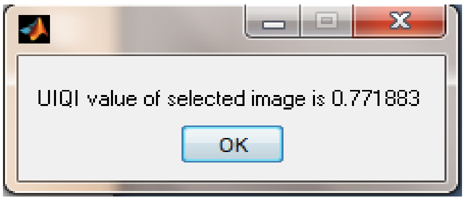


Fig 7: Displays UIQI Value

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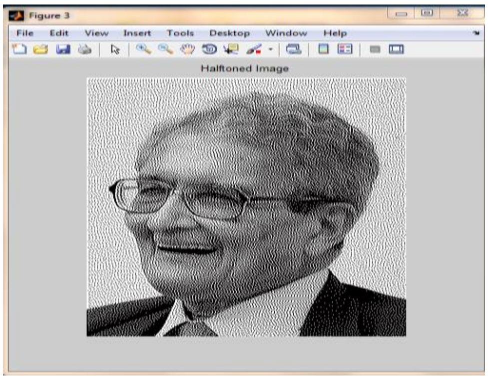

Fig 8: Shows the other Halftoned Image

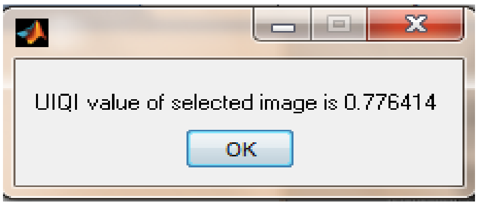

Fig 9: Displays UIQI Value of Fig 8

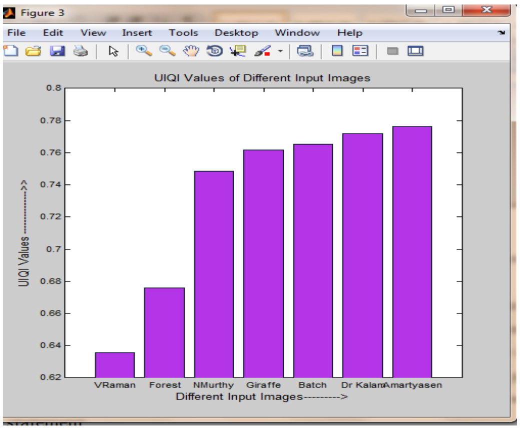

Fig 10: Shows the Comparison of the UIQI Values Of various input images

Image	Size	UIQI
 Dr.Kalam.jpg	350 ×500 ×3	0.771883
 ASen.jpg	413×336×3	0.776414
 Giraffe.jpg	440×515×3	0.761931
 Forest.jpg	1024×1536×3	0.676064
 VRaman.jpg	156×100×3	0.635847

Table 1:Different sized images and their UIQI values

Fig 6 shows the halftoned image of selected input image and Fig 7 shows its UIQI value. Fig 8 and Fig 9 shows halftoned image and its UIQI of the other image.Fig 10 shows bar graph of UIQI values of various input images considered in the list box.

6. CONCLUSIONS

The presented work is the implementation of improved error diffusion technique. Results shows the halftone obtained after using this proposed error diffusion method and errors as the starting error and diffusing errors in forward and backward direction values produces better results. All the regions which have finer details in the images are visible so the proposed method is truthful in reproducing the fine details of the actual image. The Universal Image Quality Index(UIQI) also plays an important as performance parameter. In the work did got UIQI values which ranges from 0 to 1 as shown in Table 1.Also found that this parameter is independent of size of an image. Since different images of different sizes have been considered.

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