Image Enhancement with modified Energy Equalization having a clipping limit

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ABSTRACT

In this paper, a novel method that enhances the contrast of low contrast images using the Energy Curve Equalization method along with a clipping limit [10] is modified and discussed. The modification increases the visibility of details in low light and low contrast images without over enhancing the input image. The process calculates the energies of each grey level instead of calculating the frequency of grey levels as in case of Histogram Equalization (HE). The energy curve is clipped to evade the problem of over enhancement. The clipping limit is set to the average of mean and max values of the energy curve. In the proposed method the modification is done in energy calculation and computation of clipping limit. The curve is then equalized and the new enhanced image is made using the transfer function calculated during the process. The results of the process are compared with the results of HE based methods.

*Keywords:*Contrast, Energy Curve Equalization

1. INTRODUCTION

Low contrast images have a negative effect on the visual appeal. The images appear to be dark and void of any detail. Contrast of such images need to be increased in order to make them brighter and preserve all their detail. There are many contrast enhancement techniques that have been developed. The techniques are required in order to increase the contrast of the low contrast images and preserve their details.

2. LITERATURE SURVEY

There had been a lot of contrast enhancement techniques that have been reported but the histogram equalization (HE)[1] technique is one of the most widely used among them. In the process, we plot the frequency of all the grey levels of the input image and then spread the graph evenly to produce a brighter image. The process is simple to use but it faces the problem of over enhancement of the images.
Adaptive Histogram Enhancement (AHE)[2] is a technique in whichHE process is applied on the input image by breaking the image in small parts and then applying HE individually to each block. The process eliminates the problem of over enhancement but also enhances the noise present in the image.
Contrast Limited Adaptive Histogram Enhancement (CLAHE)[3] is a technique whichfollows the process of AHE but a clipping limit is applied on the curve to limit the enhancement. This process eliminates the problem of enhancement of noise but fails to optimally enhance the image and preserve all the details.
In dualistic sub image HE (DSIHE)[4] the median brightness is preserved by breaking the graph in two parts using the median of the graph and then applying the process of equalization individually. In bi-HE (BHE)[5] the mean value is taken. In recursive sub-image HE (RSIHE) [6] and recursive mean separate HE (RMSHE) [7] the mean and median values are used to divide the histogram into four sub parts. In the updated versions of HE it is found that the brightness of the image was maintained but it failed to preserve details of the image when an image with a spikey histogram was given to them. The spikes in histogram result from parts of the image that containpixels with almost similar values. Bi-HE when used with a clipping limit (BHEPL)[8] eliminates the spikes. In all the HE methods the pixel values with higher frequency dominate the effect of values with a lower frequency. Dynamic HE (DHE)[9] was made to solve this issue, in which we divide the histogram using the value of local minima. Later on the process of Energy Equalisation with Clipping Limit (EECL) [10] was introduced. The process calculates the energy curve rather than the histogram of the image. The process of equalization is then applied on the clipped energy curve. The process preserves the detail and the brightness of the image but takes long to process the output. The proposed method is based on the same

principle of using the energy curve of the image but the method of calculation is restructured to make it faster and produce better qualitative results.

The failure of HE based methods to simultaneously preserve the brightness and the details of the image and the fact that the EECL method can be modified for better qualitative results, provides motivation for proposed method in the current paper.

The proposed method in the current paper shows the following novelties which are also the key differences from the EE method:

i. i. The equation to calculate the energy curve is modified.

ii. ii. The clipping limit is also modified to the average of mean and max values of the energy curve from the conventional clipping limit of the average of mean and median. The proposed clipping limit tends to preserve greater illumination of the image.

3. TECHNOLOGIES AND METHODOLOGIES USED

A. Energy matrix computation

We first need to calculate the B matrix for each grey level (0 to 255) for each colour channel (1 for grey image and 3 for colour image). The B matrices are calculated as follows

$$B_g = \begin{cases} +1, & if\ b_{ij} > g \\ -1, & else \end{cases} \qquad (1)$$

Here „g" denotes grey level and it ranges from 0 to 255. „b_{ij}" denotes the pixel value in the input image at row number „i" and column number „j".

We calculate B matrix for each grey level using the above equation after which we end up with 256 B matrices from B_0 to B_{255} each of which has the same resolution as the input image. Each of the B matrixes is a binary image containing values 1 or -1.

B. Calculation of energy curve

The energy curve is calculated according to the following formula

$$E_g^f = \sum_{i=1}^{M}\sum_{j=1}^{N} b_{ij} \sum_{pq \in N_{ij}^d} b_{ij} - b_{pq} \qquad (2)$$

Here „f" symbolizes the colour channel, for grey images it is set to 1 and for colour images it varies from 1 to 3. $N^d_{i,j}$ denotes the pixels in the 8 neighbourhood of the pixel under consideration (b_{ij})

The equation is applied on all of the 256 B matrices to calculate one single value from each matrix which is also the energy of that grey level. After this the values are stored in a list and plotted in a graph which is called the energy curve.

C. Clipping and Equalization

The clipping limit is calculated as the average of mean and max values of the energy curve.

$$C = (\text{mean}(E) + \max(E))/2 \qquad (3)$$

Here C is the clipping limit and E is the energy curve

Now we calculate the Probability Density Function (PDF) by dividing each element of the energy curve with the sum of all the elements.

$$\mathrm{PDF} = E_i \Big/ \sum_{i=0}^{255} E_i \qquad (4)$$

Here E_i denotes each element of energy curve. Cumulative Density Function (CDF) is calculated as the cumulative sum of the PDF.

Transfer function (T) is calculated by multiplying all elements of CDF with 255 and then the final image is made by replacing the pixels from the old image with respective pixel values from the transfer function.

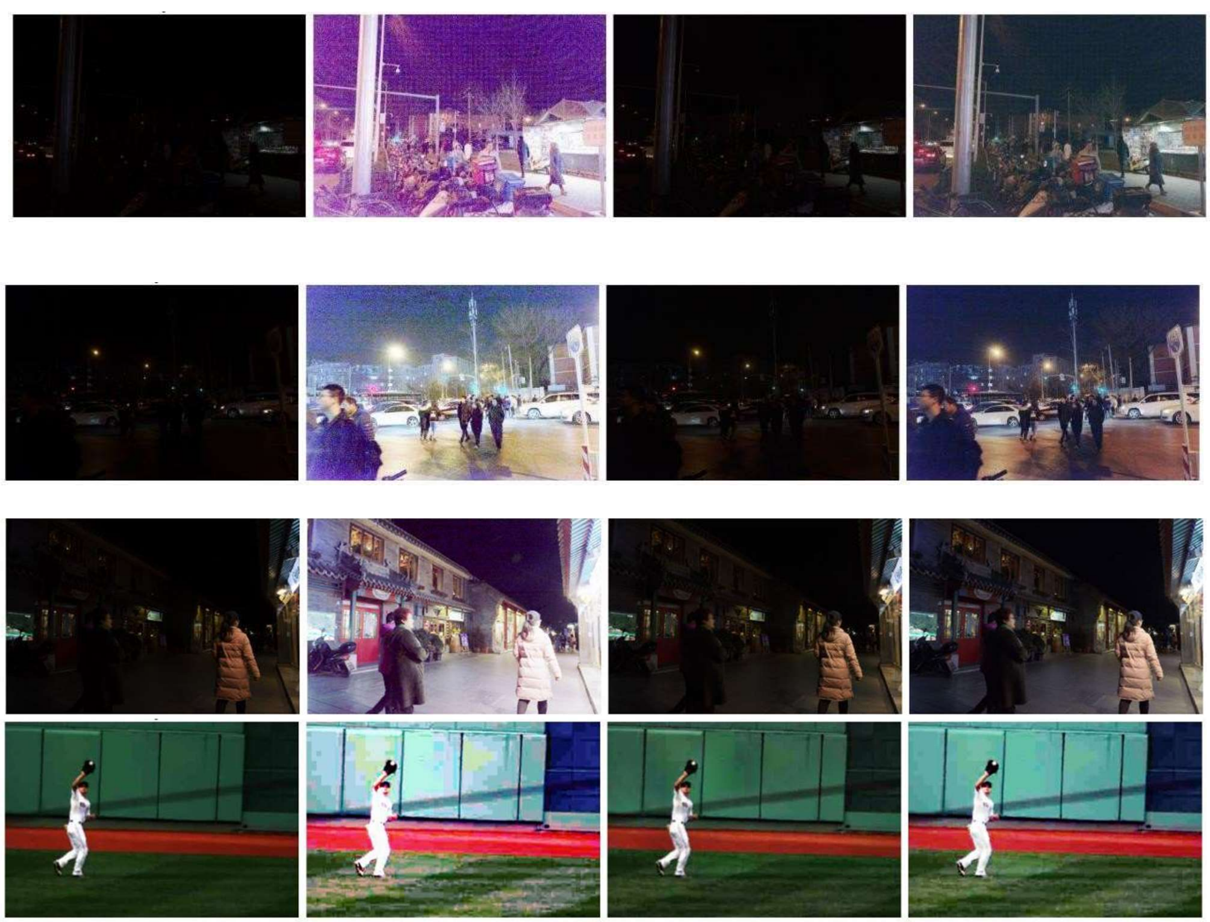
D. Proposed algorithm

Input: Low contrast image
Output: Enhanced image

Step1: Calculate 255 B matrices using equation (1).
Step 2: Apply Energy curve equation (2) individually to each B matrix and form a 1D list with the results.
Step 3: Set clipping limit using equation (3) and clip the list.
Step 4: Calculate the PDF and CDF.
Step 5: Calculate the transfer function (T).
Step 6: Make the new image by replacing old pixel values with corresponding values from T.

4. OUTPUT

In the results we have compared the results produced by HE, EECL and the proposed method. The proposed method was found to be better compared to other methods. The results are shown in Figure 1.



(a) (b) (c) (d)

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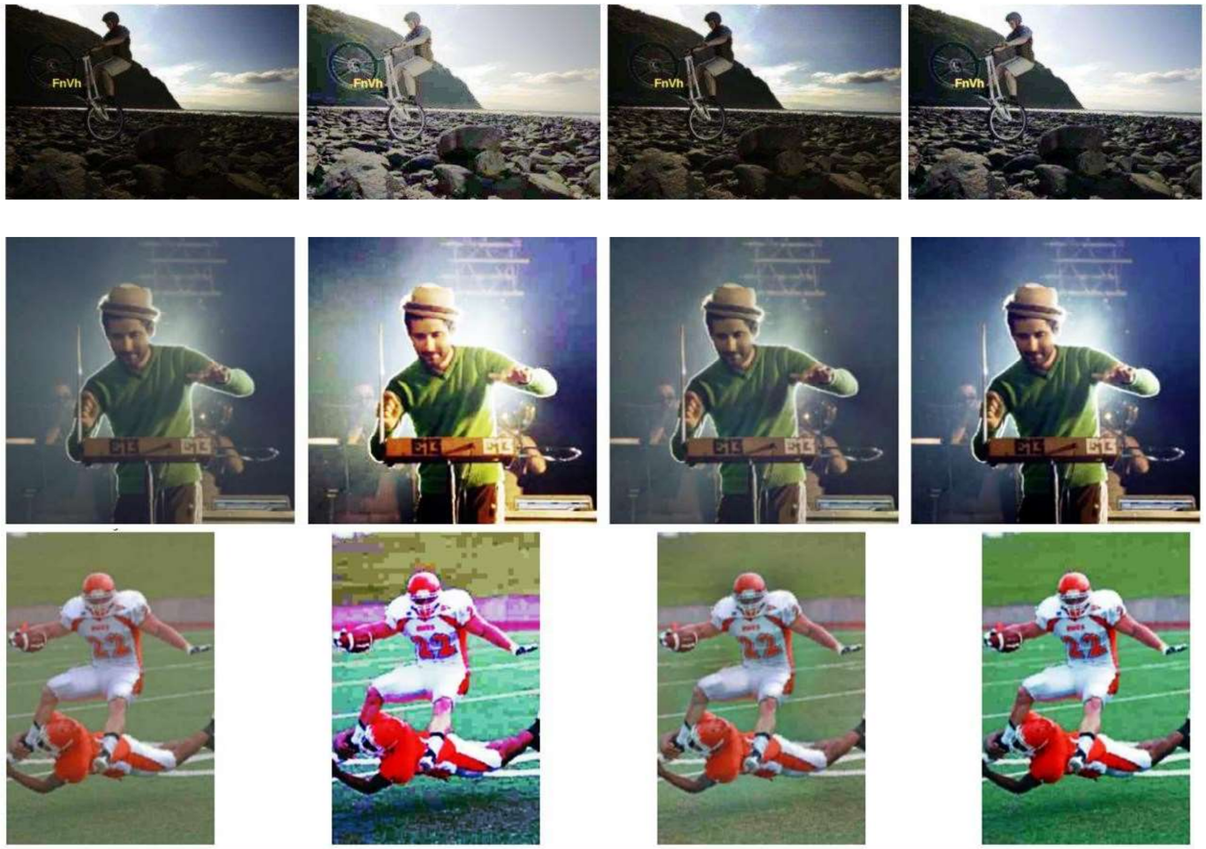

(a) (b) (c) (d)

Figure 1: Performance of the methods to the proposed method (a) Original image. Enhancement by (b) Histogram Equalization (c) By EECL [10] (d) By proposed method

5. CONCLUSION

In this paper, a new method to enhance the contrast of an image has been discussed which is a modified version of [10]. The method takes into account the energy of the grey levels in the image and forms a modified energy curve which comes out to be smoother than the histogram of the image resulting in better enhancement. The curve is also clipped at a limit which is set at the average of the mean and max values of the curve. The results approve of the fact that the proposed method enhances the contrast of the image optimally while preserving all the minute details. In future, the clipping limit can be modified so that it can work better in some extremely dark images with less to no detail. The algorithm can also be modified so that the method can eliminate any noise present in the image along with increasing contrast of the image. Currently, we are investigating the quantitative performance of the proposed method.

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