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An Efficient Method to Enhancement of Low Exposure Images Using Recursive Histogram Equalization Algorithms Using Energy Curve

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Abstract:
Image improvement is the method involved with featuring specific data of an image. Featuring as well as debilitates or eliminates superfluous data for explicit necessities. This project proposes two exposure based recursive Histogram equalization procedures for upgrade of an image utilizing energy curve. These methodologies are especially effective for the photographs that are caught in low-light circumstances, for example, submerged condition or night vision images.The first methodology is Image enhancement with Recursive Exposure-based sub-image histogram equalization (R-ESIHE) utilizing energy curve [1], which runs the ESIHE strategy recursively until the openness buildup across back to back cycles is more modest than a preset threshold.The second procedure is called Image enhancement with Recursively separated Exposure based sub-image histogram equalization (RS-ESIHE) utilizing energy curve [1], and it conducts an image histogram detachment recursively, it isolates histogram further in view of their different exposure threshold and levels each sub histogram. The recommended approaches beat past HE-based contrast improvement calculations, especially for low-light images and produce more effective sign to noise ratio.

Keywords — Recursive Histogram Equalization, Energy Curve,Image Exposure, Low Exposure Image,Image enhancement

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I. INTRODUCTION

Despite the fact that there is a progression in catching and handling of camera gadgets, still normal pictures are restricted and impacted because of low openness issues under conditions like low light, and submerged. Because of ongoing issues of camera settings like gap and shade speed caught pictures can be impacted by faint light low openness issues. The low exposure of a picture manages the dimness or brilliance of a picture. To upgrade and post-handling utilizing different picture upgrade instruments to work on the nature of a picture. Progressively numerous histogram adjustment are utilized to upgrade the picture. Histogram equalization (HE) is a generally used contrast improvement technique involved because of its simplicity of execution and straightforwardness in nature. In HE the scope of likelihood dispersion is extended over the powerful scope of grayscale. Because of the downside of HE straightforwardly applying to normal pictures can prompt an adjustment of the mean brightness to the normal level of the dark level, various strategies are proposed in which issues are being amended at various stages. The technique like CLAHE(Contrast limited adaptive histogram equalization) is unique from versatile histogram evening out which works on little areas in the picture. Subsequent to figuring different little tiles of the picture which are roughly

like the histogram by the dispersion esteem. The tiles are cumulated utilizing bi-direct insertion. Contrast upgrade of pictures goes from 0 to 1. The other proposed technique BBHE (brightness preserving bi histogram equalization) is a more proficient strategy than CLAHE which saves the mean splendor of a picture and improves the difference.

To make a low light picture more commotion free not in the least does contrast and brightness,exposure should be improved yet additionally openness is one of the key factors that should be upgraded. An Exposure manages the light condition, quality, and permeability of the picture. A recursive technique to work on low-openness pictures. The principal strategy R-ESIHE (Recursive exposure-based sub-image histogram equalization) in which recursively cycles are performed on the picture until the openness is down to a characterized edge esteem. Different strategies RS-ESIHE (Recursive separated exposure-based sub-image histogram equalization) in which histogram into many sub histograms in light of exposure of individual limit of tiles and performs histogram adjustment of sub histogram. Thus cutting of pictures is added to restrict over upgrade. Notwithstanding the above-proposed strategy, the energy curve is being supplanted with the histogram of an image, and equalization is performed on the images.

II. LITERATURE REVIEW

The previous level method i.e., CLAHE and BBHE could not perform as efficiently during low exposure and underwater condition.

A. CLAHE

Because of the absence of post-handling issues caught images might restrict interestingly, because of the low contrast picture perception of the picture is debased. Contrast enhancement means concocting a seriously satisfying picture to check more visual data out. The contrast enhancement is utilized to perform procedures on low exposure and faint light picture to improve the contrast of the picture. An adaptive histogram leveling strategy that performs contrast improvement on little tiles of a picture instead of the general picture. The tiles are coordinated by the dispersed scope of values finally all the scope of values are consolidated and produce more contrast improved pictures utilizing bilinear introduction.

B. BBHE

The BBHE is employed to operate on low brightness and dim light image.BBHE is also and histograms equalization method which operates on the mean brightness of the image which divides the histogram according to average brightness and performs equalization. However, there is some issue drawback with the above method which cannot do a satisfactory process for some situation like underwater and low exposure condition.

III. PROPOSED METHOD

Proposed method could overcome the issue raised by previous method and can handle the different condition more effectively.

A. Energy Curve

The energy curve of an image is a measure of error or distance from the ideal. [2]Let an image $I = x(i,j)$, i and j where, $i = 1,2,3,\ldots N$ and $j = 1,2,3,\ldots M$, $M * N$ are size dimension of an image and, where X is the maximum pixel value of an image I.image I is defined by N of order d, for an image (i,j) as $N_{ij}^{d} = \{(i+u, j+v), (u,v) \in N^{d}\}$. The subsystem are used to determine the energy curve of an image,i.e.,$(u,v) \in \{(\pm 1,0), (0,\pm 1), (1,\pm 1), (-1,\pm 1)\}$.

Firstly calculate the energy of each pixel for entire grayscale range and generate a binary matric.

$B_x = \{b_{ij}, 1 \le i \le M, 1 \le j \le N\}$,the $b_{ij} = 1$ if $X_{ij} > x$;else $b_{ij} = -1$ .let $C = \{c_{ij}, 1 \le i \le M, 1 \le j \le N\}$ other matric is $c_{ij} = 1, \forall (i,j)$.At each pixel X,energy value E(K),of the image I as given below

$$E(K) = -\sum_{i=1}^{M}\sum_{j=1}^{N}\sum_{pq \in N^{2}_{ij}} b_{ij}b_{pq} + \sum_{i=1}^{M}\sum_{j=1}^{N}\sum_{pq \in N^{2}_{ij}} c_{ij}c_{pq} \qquad (1)$$

[2] The $[t_1, t_2]$represents the pixel range of an image I, for $x = t_1$, B_x= 1. As the X value increases for a few elements matrix B_x be -1 .if $x = t_2$, then the $B_x$be -1.The raw image is adjusted according to the range and the energy curve is calculated over the grayscale range from 0 to 255 i.e., E(K).

B. Proposed method 1(Image Enhancement using Energy curve).

Most recursive methods are evaluated according to the average histogram of the image this paper operates a recursive histogram using the energy curve of the image. The natural energy curve of raw images is not satisfactory and no visualization. The R-ESIHE is performed on the energy curve of the image to make it more information for visualization and controlled exposure.

a) Exposure of image is calculation

$$\boldsymbol{exposure} = \frac{\sum_{K=0}^{L-1} E(K)K}{L\sum_{K=0}^{L-1} E(K)} \qquad (2)$$

Where E is the energy curve and L is the total number of gray scales. the boundary value X_i which split the image into under and over an exposed image on exposure. The level of exposure is from 0 to if the value is down or less than 0.5 then it is an underexposed image and greater than 0.5 is the overexposed image.

$$\boldsymbol{X_i = L(1 - exposure)} \qquad (3)$$

b) Energy curve of image

The energy curve of the image is calculated by E.Which is used for clipping of image and threshold calculation. The image is calculated over grayscale into 2-D matrix size all the values of the binomial image are combined.Clipping of image.

Mean of energy value are computed Xpdf and threshold value are compared.

$$T_c = \frac{1}{L}\sum_{K=0}^{L-1} E(K) \qquad (4)$$

$$E_c(K) = \begin{cases} E(K), E(K) < T_c \\ T_c, \quad\ E(K) \ge T_c \end{cases} \qquad (5)$$

c) Sub division and equalization

The natural image is divided to WL an WU from gray scale 0 to X_i-1 and X_i to L-1 according to exposure threshold value X_i.The PDF of sub images are defined by $P_L(K)$ and $P_U(K)$ equation 6 and 7.

$$P_L(K) = E_c(K)/N_L \text{ for } 0 \le K \le X_i\text{- }1 \quad (6)$$

$$P_U(K) = E_c(K)/N_U \text{ for } X_i \le K \le L\text{ - }1 \quad (7)$$

Where N_L and N_U are total number of pixels.

Then CDF of individual images are defined as $C_L(K)$ and $C_U(K)$ equation 8 and 9.

$$C_L(K) = \sum_{K=0}^{X_i-1} P_L(K) \quad (8)$$

$$C_U(K) = \sum_{K=X_i}^{L-1} P_U(K) \quad (9)$$

Equalize and transform four sub images to single image based on transfer function

$$F_L = X_i C_L \quad (10)$$

$$F_U = (X_i + 1) + (L - X_i + 1)C_U \quad (11)$$

Where F_L and F_U are transfer function.

- *Algorithm of proposed method 1*

i. Compute the energy curve E(K) of the image.
ii. Calculate the exposure and threshold value X_i.
iii. Perform clipping based on threshold T_c and clip the energy $E_c(K)$.
iv. Diverge the curve to two sub sector using threshold X_i.
v. Apply histogram equalization on individual sector.
vi. Combine sub images to single image.
vii. Repeat the steps until exposure difference is less than threshold value.

C. Proposed method 2 (Image Enhancement using Energy curve).

The RSESIHE perform recursive decomposition of energy based on exposure to individual sub sector up to the recursion level of 2r.RSESIHE initially divide the image to sub images and the perform recursion operation.

a) Exposure of image is calculation

As per equation 2 X_i is calculated.Again to more exposure value are calculated on two sub individual images X_{iL} and X_{iU}.

$$X_{iL} = L\left[\frac{X_i}{L} - \frac{\sum_0^{X_i-1} E(K)K}{L\sum_0^{X_i-1} E_c(K)}\right] \quad (12)$$

$$X_{iU} = L\left[1 + \frac{X_i}{L} - \frac{\sum_{X_i}^{L-1} E(K)K}{L\sum_{X_i}^{L-1} E_c(K)}\right] \quad (13)$$

b) Sub division and equalization

The expose of image is calculated using equation 3 X_i.The individual sum images are decomposed to two more smaller sub images based on individual expose X_{iL} and X_{iU}.The sub divided images ranges as W_{Ll},W_{Lu},W_{Ul} and W_{Uu} for gray level 0 to X_{iL} - 1,X_{iL} to X_i - 1,X_i to X_{iU} - 1,X_{iU} to L - 1.

The PDF are $P_{Ll}(K)$, $P_{Lu}(K)$, $P_{Ul}(K)$ and $P_{Uu}(K)$ equation 14,15,16 and 17.

$$P_{Ll}(K) = E_c(K)/N_{Ll} \text{ for } 0 \le K \le X_{iL} - 1 \quad (14)$$

$$P_{Lu}(K) = E_c(K)/N_{Lu} \text{ for} X_{iL} \le K \le X_i - 1 \quad (15)$$

$$P_{Ul}(K) = E_c(K)/N_{Ul} \text{ for} X_i \le K \le X_{iu} - 1 \quad (16)$$

$$P_{Uu}(K) = E_c(K)/N_{Uu} \text{ for} X_{iU} \le K \le L - 1 \quad (17)$$

Where N_{Ll}, N_{Lu}, N_{Ul} and N_{Uu} are total number of pixel in sub images.

The CDF of individual sub images are defined as $C_{Ll}(K)$,$C_{Lu}(K)$,$C_{Ul}(K)$ and $C_{Uu}(K)$ equation 18,19,20 and 21.

$$C_{Ll}(K) = \sum_{K=0}^{X_i - 1} P_{Ll}(K) \quad (18)$$

$$C_{Lu}(K) = \sum_{K=X_{il}}^{X_i - 1} P_{Lu}(K) \quad (19)$$

$$C_{Ul}(K) = \sum_{K=X_i}^{X_i - 1} P_{Ul}(K) \quad (20)$$

$$C_{Uu}(K) = \sum_{K=X_{iu}}^{L-1} P_{Uu}(K) \quad (21)$$

Equalize of all four sub images using transfer function

$$F_{Ll} = X_{il} C_{Ll} \quad (22)$$

$$F_{Lu} = (X_{il} + 1) + (X_i - X_{il} + 1)C_{Lu} \quad (23)$$

$$F_{Ul} = (X_i + 1) + (X_{iu} - X_i + 1)C_{Ul} \quad (24)$$

$$F_{Uu} = (X_{iu} + 1) + (L - X_{iu} + 1)C_{Uu} \quad (25)$$

Where F_{Ll},F_{Lu},F_{Ul} and F_{Uu} are transfer function.

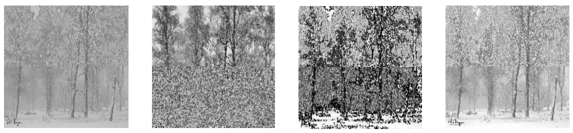
- *Algorithm of proposed method 2*

i. Compute the energy curve E(K) of the image.
ii. Calculate the exposure and threshold value X_i.
iii. Perform clipping based on threshold T_c and clip the energy $E_c(K)$.
iv. Diverge the curve to two sub sector using threshold X_i.
v. Compute exposure of sub images X_{iL} and X_{iU} dividing based on decomposed threshold.
vi. Apply histogram equalization on individual sector.
vii. Combine sub images to single image.

IV. RESULT

The results are compared to the current histogram leveling technique i.e., CLAHE and BBHE. The considered test pictures are fish2, Mosque, and in are taken.

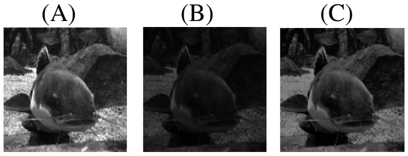
a. comparison based on visual quality



(A) (B) (C) (D)

(E) (F) (G)

(A) (B) (C) (D)



(A) (B) (C) (D)

(E) (F) (G)

(E) (F) (G)

Fig. 1 Results of Fish (A) original, (B) CLAHE,(C) BBHE, (D)R-ESIHE, (E)RS-ESIHE,(F) Proposed method 1 and (G)Proposed method 2

By analysis of visual information compared to other methods recursive methods using energy curves had produced much more quality images in terms of visualization. Other methods face difficulty during low exposure and dim light condition where the recursive method adjusted exposure and produced an efficient output image.By using energy curve, noise produced in the image is also low.

b. comparison based on average entropy

Fig. 2 Results of Mosque (A) original, (B)CLAHE,(C) BBHE, (D)R-ESIHE, (E)RS-ESIHE, (F)Proposed method 1 and (G)Proposed method 2.

The entropy is the roughness of animage which measures the details of the image. As entropy is higher the details in the image are greater and if they are close to the original context the performance is optimum.The entropy value are tabulated below

TABLE I. AVERAGE ENTROPY RESULTS

Images	Original	CLAHE	BBHE	R-ESIHE	RS-ESIHE	Proposed method 1	Proposed method 2
Fish	4.490	5.980	4.484	4.489	4.490	4.490	4.484
Mosque	6.263	7.234	6.127	6.258	6.223	6.257	6.185
In	6.277	7.467	6.195	6.246	6.079	6.196	5.902
Average	5.676	6.893	5.602	5.664	5.597	5.647	5.523

By analysis of the above table proposed method is more optimum performance than CLAHE and greater in details context compared to existing methods. The overall proposed method is moderate in performance, With average entropy values of 5.647 and 5.523.

c. comparison based on PSNR

Fig. 3 Results of In (A) original, (B)CLAHE,(C) BBHE, (D)R-ESIHE, (E)RS-ESIHE, (F)Proposed method 1 and (G)Proposed method 2.

The PSNR (Probability of signal to noise ratio) which define error present with respect to the original image.The greater the value of PSNR better the quality of reconstructed image.

The values of PSNR are tabulated below

TABLE II. AVERAGE PSNR RESULTS

Images	CLAHE	BBHE	R-ESIHE	RS-ESIHE	Proposed method 1	Proposed method 2
Fish	21.020	9.830	9.753	6.161	25.003	14.063
Mosque	15.787	10.532	11.110	12.912	17.239	17.042
In	18.298	12.889	20.420	22.498	16.635	25.617
Average	18.368	11.083	13.761	13.857	19.625	18.907

By analysis of above average PSNR proposed methods have resulted high PSNR value which define better signal to noise ratio compared to existing method.With highest PSNR value of 19.625 and 18.907 which provide better image to noise quality.

V. CONCLUSION

To the experimental result, the proposed method performs an efficient histogram equalization technique with the help of an energy curve. Due to complications during post-processing camera settings, it can not provide good quality images during some conditions like low exposure, low light and underwater condition. By the existing methods efficient image processing during low light and underwater conditions, cannot provide a more comfortable vision as well as noise in the image. To override the issue faced by the existing method the proposed method help to solve low exposure enigma and provide efficient results. We have implemented the energy curve of the image for histogram equalization. During the decomposition of the histogram based on the exposure threshold value energy curve provides a very efficient dynamic range and produces better results in visual information, average entropy, and average PSNR value.

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