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Image Enhancement Based On Multi Decomposition Dualistic Subimage Histogram Equalization

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Abstract:

There are many algorithms for image contrast enhancement one of these algorithm Histogram Equalization algorithm (HE), but it has some disadvantages, for this reason, there are many techniques for eliminate drawbacks of HE. The techniques can be classified into global histogram equalization and local histogram equalization. This paper produce one of global histogram equalization technique based on median, proposed method work to segment image into multi subimage by taking median of image as threshold for segmentation and use weighted model depend on weighted Probability Distribution Function (PDF) of the image for preserving brightness of image of the results of the experiment found that the proposed method achieved better results than the technique compared with it such as (HE, DSIHE, BHE, MMSICHE). The results of the measurements used for the proposed method (PSNR=85%), (SNR=100%), (AMBE=83%)and (SSIM=98%).

Keywords: Contrast enhancement, histogram equalization, DSIHE.

1.Introduction

Image enhancement aims to improve human perception and interpretability of information in images or to provide more useful input for other automated image processing techniques [1].
Image contrast enhancement is an important problem in low level image processing. The quality of the acquired image is not good enough due to the restrictions of background and light conditions as well as those of the camera devices. With the help of image enhancement technology, one can improve the visual effect of the image or enhance some specific information in image, so as to benefit the object recognition and image understanding [2].
Histogram Equalization (HE) is one of spatial domain contrast enhancement method and extensively utilized because of its simplicity, ease of implementation and effectiveness. Also it should be mentioned that histogram based techniques is much less expensive comparing to the other methods [2].
Histogram Equalization (HE) method has disadvantages which affect efficiency of this method .Like, it assigns one gray level for different neighbor gray levels with different intensities higher intensity to that gray level and it gives washed out appearance to the output image, it is undifferentiating between the various pixels, that is, while increasing the contrast of its background, the signal gets distorted, histogram equalization often produces unrealistic and unlikely effects in photographs[3]. For solving the problems, some techniques have been proposed. First type of this technique is, Global Histogram equalization(GHE), which uses properties, like, (mean and median), for example using Bi-Histogram Equalization (BHE) algorithm instead of Histogram Equalization (HE). BHE separates the input image/video histogram into two parts based on input mean before equalizing them independently [4]. Dualistic Sub Image Histogram Equalization (DSIHE). In this method, first histogram is divided to segments based on median and then histogram equalization method is applied on each segment separately [4,5].
The second type is, Local Histogram Equalization, this method with image division. These methods firstly divide image into many sub-images and then equalize them individually, for example, Adaptive Histogram Equalization (AHE), Contrast Limited Adaptive Histogram Equalization (CLAHE) this type has disadvantage such as AHE has a behavior of amplifying noise, thus limiting its use for homogeneous figures. Its advanced form is contrast limited adaptive histogram equalization (CLAHE) that eliminated the above problem.but fails to retain the brightness with respect to the input image [6].
The rest of this paper is organized as follows: Section2 introduces the Histogram Equalization Algorithm. Section3 Section describes Dualistic Sub-Image Histogram Equalization DSIHE, section4 Image enhancement via Median-Mean Based Sub-Image-Clipped Histogram Equalization (MMSICHE), Section5 then describes Histogram Weighted Model Next, section6 presents Proposed algorithm section7 imply image enhancement parameter section8, the experimental results, section, and Conclusions are finally drawn in Section 9.

2. Histogram Equalization Algorithm

HE is the fundamental technique for image processing. The aim of this algorithm is to distribute the given number of gray levels over a range uniformly distributed, thus enhancing its contrast HE is one of spatial domain contrast enhancement method [7].

Consider a digital image X with gray levels in the range [0, L −1], Probability Distribution Function (PDF) of the image can be computed as equation bellow [4]:

$P(r_k) = \frac{n_k}{N}$ (1)

k =0, 1,…L-1

Where r_k is the k_{th} gray level and n_k is the number of pixels in the image having gray level r_k, N is the total number of pixel.

Cumulative Distribution Function (CDF) can also be computed as followed:

$C(r_k) = \sum_{i=0}^{i=k} P(r_i)$ (2)

k=0,1,2,….L-1 ,0≤ $C(r_k)$ ≤1

Histogram Equalization (HE) appropriates gray level rk to gray level s_k of the input image using equation:

$S_k = X_0 + (X_{l-1} - X_0) \times C(r_k)$ (3)

3. Dualistic Sub-Image Histogram Equalization (DSIHE)

DSIHE and BBHE is similar, except that the threshold for segmentation is the median in DSIHE and mean in BBHE of the input image (X). That is, the input histogram H(X) is partitioned into two sub-histograms HL(X) and HU (X) input median XD. Each of HL (X) and HU (X) is then equalized independently as in BBHE [2,3,8]

If use the median of the image to segment the original image. The median is denoted as a gray scale X_m where the cumulative density function equals to 0.5 [3]. For computing X_m consider a variable x(k) as calculated in (2):

$x(k) = x(k-1) + p(r_k)$ (4)

While median compute as equation follow:

$Xm = \arg_k min|x(k) - 0.5|$ (5)

Then, according to $X_{m\ the}$ image X is divided into sub image X_L and X_R which is given in equation (6) and (7)

X_L={X where X<=X_m} ..(6)

X_R={X where X >X_m} (7)

4. Image enhancement via Median-Mean Based Sub-Image-Clipped Histogram Equalization (MMSICHE).

A robust contrast enhancement algorithm based on histogram equalization methods. This algorithm consists of three steps [9]:

Input: orginal image X

Output: enhanced image

Step1: calculate median of image X_m

Step2: devide image histogram based on median to two sub image X_L, XR

Step3: calculate mean to XL, XR to get XmL, XmR

Step4: clipping histogram by take X_m as threshold for clipping through any value in orginal histogram greater than X_m are limiting to X_m.

5. Weighted Model

Proposed technique depend on preserving brightness simple model depend on PDF for speed up computation speed and aim to keeping effect of grayscale in image.

The range of input image histogram is [0 L-1]. The probabilities P(k) of each histogram are modified with weighted probabilities Pw(k) as per the equation:

$$P_w(k) = \frac{p_k}{\sum_{i=0}^{L-1} p_k} \quad (8)$$

6.Proposed Technique

The proposed technique based on median of image which represent as an intensity value of image where the cumulative density function is 0.5, through divide the input image for a fixed number of times by taking the median threshold in the division and then applying the histogram equalization to each part of the image.

Histogram Equalization process works only on the illumination. The proposed technique uses the weighted model to increase the brightness and keeping affect each graylevel fixed as possible, the final step is to assemble each subimage to find the improved final image as imply in figure (1).

The steps of the propose technique: -

Input: image X
Output: enhanced image
Step1: Convert image to one-dimension matrix
Step2: Compute median to one-dimension matrix and segment it to two part
Step3: Depending on median value (X_m) find: -
X_L= {X where $X<=X_m$}
X_R= {X where $X>X_m$}
Where X_L:value of image less or equal than median
X_R: value of image greater than median
Step4: For every subimage repeat the third and fourth steps for four iterations at end the image is divided for eight segments.
Step5: For every segment implement Histogram Equalization.
Step6: Compute Weighted Histogram to normalize the result of Histogram Equalization.
Step7: Final step interpolation new value of graylevel to get output image

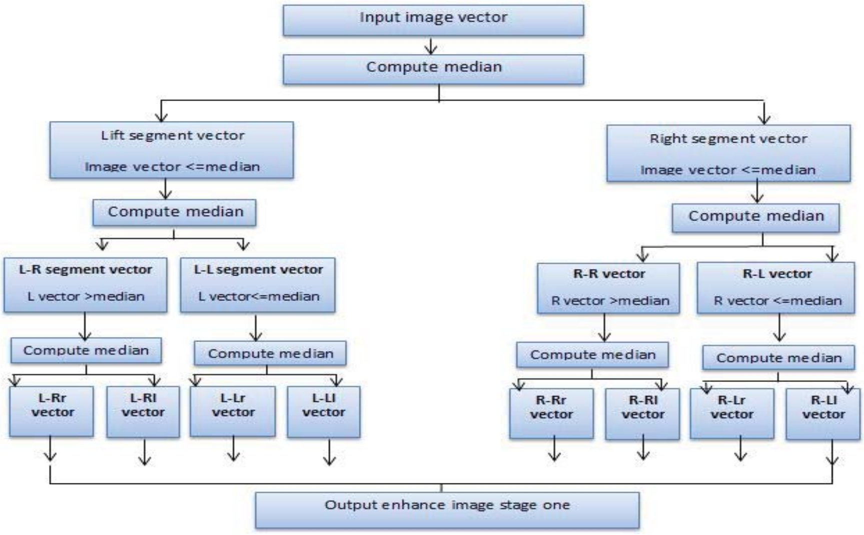

Figure (1) flowchart for proposed method

7. Result and Discussion

In this section the performance of the proposed contrast enhancement technique is compared with the other existing histogram equalization. Low contrast test images are utilized for the assessment of visual quality and performance of the proposed technique. This technique has been implemented by using MATLAB version R2014a.

Performance of proposed technique is measured using Image Enhancement Parameters such as Peak Signal to Noise Ratio (PSNR), Signal to Noise Ratio (SNR), Absolute Mean Brightness Error(AMBE), and Structural Similarity Index Matrix (SSIM).

Series of experiments has been performed to evaluate the performance and feasibility of the proposed technique. For quantitative evaluation, Table 1- 4 shows the result of PSNR, SNR, AMBE, SSIM on bad contrast images. Comparison of visual quality and appearance of the test images are shown in Fig. 2 and 3

7.1 Performance measurement

a. Peak signal to noise ratio (PSNR):

PSNR is the evaluation standard of the reconstructed image quality, and it is considering important measurement feature is given by [4]:

$$\mathrm{PSNR} = 10\log_{10}\left(\frac{(L-1)^2}{MSE}\right) \ldots\ldots(9)$$

where (L) is maximum possible graylevel that can be attained by the image signal. Mean square error (MSE) is defined as Where(M*N) is the size of the input image. Higher the PSNR value is better the reconstructed image is[4,10].

b. Signal to Noise Ratio (SNR)

SNR gives the relation between required signal level and surrounding noise level. It is defined as the ratio of signal power to noise power. A ratio of higher than 1:1 is regarded as a well signaled ratio. It is measured in Decibels. Represented as [11]: -

$$SNR = \frac{\sum_{i=0}^{M-1}\sum_{j=0}^{N-1} r(i,j)^2}{\sum_{i=0}^{M-1}\sum_{j=0}^{N-1} n(i,j)^2} \ldots..(10)$$

Where n (i; j) = r (i; j) - e (i; j)
r (i, j): orginal gray level
e (i, j): error in image
n (i, j): enhance gray level

c. Absolute Mean Brightness Error (AMBE)

AMBE defined difference in mean brightness of input image and mean brightness of output image. When image is over enhanced unwanted artifact will be created, brightness of the output image changes and image will lose its natural appearance. That is lesser the value of AMBE better the equality of image [3,10].

Let μ_X be mean brightness of input image and μ_Y be mean brightness of output image. AMBE can be given by equation as in

$$AMBE = |\mu_x - \mu_y| \quad (11)$$

$$\mu x = \sum_{x=0}^{L-1} X * p(Y) \quad (12)$$

$$\mu y = \sum_{y=0}^{L-1} Y * p(Y) \quad (13)$$

P(X), p(Y): Probability Density Function of Input and output image gray levels respectively

d. Structural Similarity Index Matrix(SSIM)

Structural Similarity Index Matrix to assess the image quality is defined as:

$$SSIM = \frac{(2\mu x\mu y + C_1)(2\sigma_{xy} + C_2)}{(\mu_x^2 + \mu_y^2 + C_1)(\sigma_x^2 + \sigma_y^2 + C_2)} \quad (14)$$

where x and y are the input and the output images respectively; μ_x is the mean of image x, μ_y is the mean of image y. σ_x is the standard deviation of image x and σ_y is the standard deviation of image y, $\sigma_{xy}$is the square root of covariance of images x and y, C1 and C2 are constants. The SSIM value between two images x and y is generally in the range zero to one. If the image x=y then the SSIM=1 which implies that when the SSIM value of two images is nearing 1, the degree of structural similarity between the two is higher [12].

7.2 Quantitative Comparison

The proposed algorithm applied on a database which includes 100 normal images with jpg form and with same size (256*256). The taking image have various condition some of these image have uniform background and other have one or more object in background and in various illumination condition. Figure (2) imply sample of using image.

In this subsection, imply the effectiveness of proposed method from a qualitative point of view.

The qualitative performance of proposed method is illustrated using (orginal1.jpg) image and its histogram which is given in Figure (3). The enhanced images of the same by HE, BBHE, DSIHE, MEAN_MEDAIN, and proposed technique

In order to comprehensively reflect the advantages of proposed technique, select four performance assessment indices as follow: -

From Table1 PSNR value for image comparing propose method with other method and result of performance of image is 85% From Tables2 SNR value notice proposed method produce rate of performance 100%If notice Tables3 find value of of SSIM comparing with other method find rate of proposed method is 98% and rate of AMBE is 83%.

Table1. PSNR results of image contrast enhancement using different techniques

image name	HE	DSIHE	BHE	Mean-Median	**proposed method**
orginal1	11.84743	13.22540	12.95860	19.52336234	**20.71819632**
orginal 2	12.39395	13.51840	12.95830	18.08147383	**20.28805926**
orginal 3	11.31710	13.56890	13.32640	20.09978081	**20.2482913**
orginal 4	12.38123	11.77560	12.82670	20.51360021	**20.57785017**
orginal 5	7.82198	21.15990	20.85130	15.82356052	**23.30177775**
orginal 6	13.39981	11.46990	14.51690	20.2140166	**21.25662369**
orginal 7	14.74945	12.26990	11.82550	23.23068634	**25.66450969**
orginal 8	12.65878	9.94310	10.76140	18.73570188	**19.74604222**
orginal 9	11.74989	12.10930	12.81820	18.7268522	**19.02101379**
orginal 10	13.83257	14.04210	14.12770	19.37779582	**21.73167807**
orginal 11	12.86613	11.14310	10.72650	20.11577469	**20.255664**
orginal 12	11.73065	14.41290	13.74920	21.79792146	**23.58137412**
orginal 13	14.66808	15.11670	14.85760	19.04745625	**21.06618443**
orginal 14	11.73178	11.60660	12.60480	17.30988399	**18.25548018**
orginal 15	12.64842	8.65720	8.48380	19.21033445	**19.87885594**
orginal 16	13.00396	10.59110	10.32860	19.08435694	**19.72264256**
orginal 17	11.50412	10.67700	10.67700	17.11884039	**17.9656794**
orginal 18	11.86287	11.29810	10.84050	19.35760248	**18.85902751**
orginal 19	12.93424	10.55620	12.10710	18.48984352	**19.6650406**
orginal 20	14.07901	11.84940	11.42870	20.28378506	**21.07406989**

Table2. SNR results of image contrast enhancement using different techniques

image name	HE	DSIHE	BHE	Mean-Median	**proposed method**
orginal1	12.26877	7.528	7.6334	17.26580525	**18.06103843**
orginal 2	12.27635	7.7105	7.823	15.23889853	**16.84831221**
orginal 3	12.26068	7.5962	7.6995	18.07984842	**18.15390176**
orginal 4	12.23614	7.541	7.5855	18.27062632	**18.47430465**
orginal 5	11.90527	10.5662	8.9696	15.08679809	**16.67155823**
orginal 6	12.24268	7.5353	8.0092	17.07478457	**18.00354959**
orginal 7	12.25646	7.3054	7.3269	15.88361303	**16.72805681**
orginal 8	12.25805	7.6585	7.6367	17.50389046	**18.54767771**
orginal 9	12.26446	7.7695	7.6941	17.88624085	**18.25225782**

orginal 10	12.26055	7.2873	7.2979	14.71970017	**16.13961014**
orginal 11	12.24733	7.4612	7.5502	17.77354942	**18.09483517**
orginal 12	12.28253	7.5994	7.8855	15.20532785	**16.09746936**
orginal 13	12.26602	7.5729	7.6831	13.67101647	**15.04206767**
orginal 14	12.25151	9.0679	8.9269	17.36637319	**18.24203496**
orginal 15	12.26127	7.294	7.3567	16.97130118	**17.66955434**
orginal 16	12.29412	7.988	7.9915	17.2289456	**18.02622169**
orginal 17	12.30873	8.4947	8.4947	18.07236645	**19.17992024**
orginal 18	12.2827	7.9751	8.0161	18.97158004	**18.7232267**
orginal 19	12.25786	7.4491	7.7331	16.86341761	**18.14705019**
orginal 20	12.2477	7.35	7.3533	16.3958419	**17.07002177**

Table3. SSIM results of image contrast enhancement using different techniques

image name	HE	DSIHE	BHE	Mean-Medain	**proposed method**
orginal1	0.54560852	0.329	0.312	0.822829146	**0.874668804**
orginal 2	0.70109793	0.415	0.377	0.850190231	**0.841637792**
orginal 3	0.46407314	0.306	0.29	0.816587469	**0.842455465**
orginal 4	0.57760578	0.373	0.434	0.805884781	**0.855109449**
orginal 5	0.38223305	0.495	0.447	0.827499616	**0.883708746**
orginal 6	0.65020336	0.4	0.605	0.788736329	**0.857321154**
orginal 7	0.65295759	0.218	0.199	0.884735196	**0.939358189**
orginal 8	0.54493253	0.346	0.413	0.758955888	**0.810606082**
orginal 9	0.48490778	0.301	0.357	0.763887844	**0.818042183**
orginal 10	0.79459752	0.396	0.402	0.827225812	**0.88314139**
orginal 11	0.53001745	0.319	0.294	0.771050583	**0.794006842**
orginal 12	0.72592255	0.342	0.248	0.888849876	**0.922928292**
orginal 13	0.7714025	0.515	0.512	0.865395176	**0.869170585**
orginal 14	0.58911027	0.45	0.508	0.774076936	**0.800937535**
orginal 15	0.51877165	0.281	0.268	0.759246022	**0.818728484**
orginal 16	0.54707783	0.321	0.299	0.729538411	**0.771660836**
orginal 17	0.46933867	0.392	0.392	0.649387872	**0.688324692**
orginal 18	0.30393718	0.212	0.191	0.57933319	**0.560824611**
orginal 19	0.57919492	0.353	0.487	0.743551538	**0.798271961**
orginal 20	0.70786186	0.397	0.367	0.856291865	**0.864626553**

Table3. AMBE results of image contrast enhancement using different techniques

image name	HE	DSIHE	BHE	mean+median	**proposed method**
orginal1	34.31758118	43.009	44.9784	6.08303833	**2.327819824**
orginal 2	35.69015503	46.454	49.9083	7.890762329	**0.085571289**

orginal 3	38.62834167	40.658	42.3125	6.166549683	**2.256515503**
orginal 4	22.11303711	48.693	40.7936	3.77130127	**0.873077393**
orginal 5	88.93685764	15.766	18.0748	16.95758681	**18.0628125**
orginal 6	14.21160889	48.485	32.3721	3.990447998	**0.495513916**
orginal 7	22.19657898	52.916	56.2942	3.898849487	**0.812591553**
orginal 8	0.580062866	59.281	51.6499	2.671112061	**2.990707397**
orginal 9	26.62442017	46.017	40.6909	4.483169556	**1.200424194**
orginal 10	34.49342346	43.645	43.3003	9.838912964	**2.815887451**
orginal 11	11.95605469	55.457	59.3445	1.67805481	**2.196609497**
orginal 12	49.94085693	40.451	46.1154	3.92817688	**1.953399658**
orginal 13	31.74230957	41.453	43.5122	6.778503418	**1.348846436**
orginal 14	15.61296875	45.464	35.8396	6.089965278	**1.423576389**
orginal 15	24.34449653	73.213	75.2805	3.372725694	**5.403697917**
orginal 16	5.976882935	58.185	60.8712	0.287780762	**3.04359436**
orginal 17	6.431259155	49.684	49.6835	3.872344971	**7.938369751**
orginal 18	15.58158875	52.184	56.2586	1.697647095	**3.982589722**
orginal 19	5.593292236	55.008	42.9154	4.790618896	**3.040039063**
orginal 20	14.88829041	55.256	58.1724	5.712097168	**0.634979248**

Fiqure2. Sample of using image

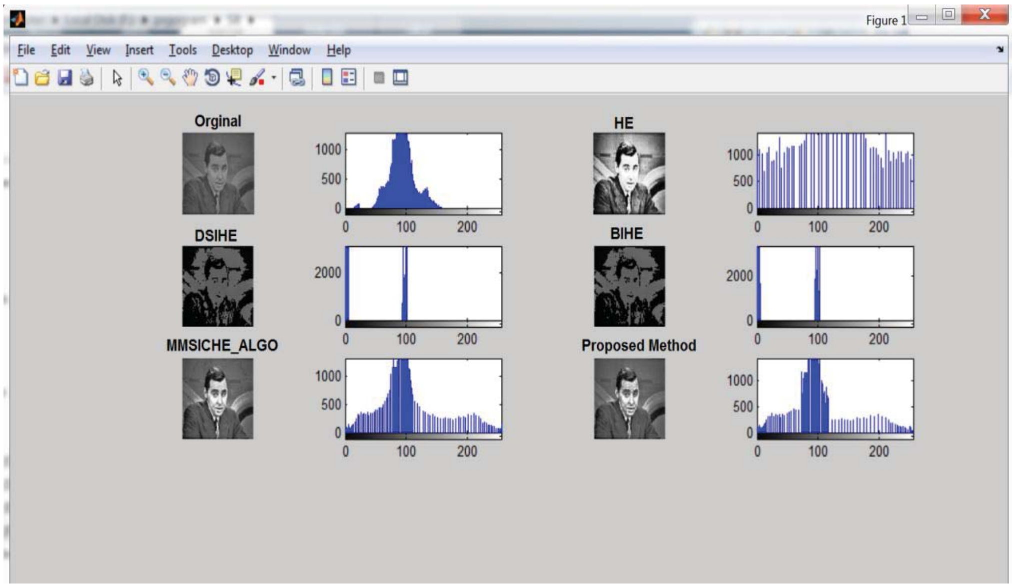

Figure3. Enhancement result of orginal1.jpg image in different technique

8. Conclusions and future applications

HE work on four parameters :(saturation, contrast, brightness and sharpness). Proposed method work on two parameters for enhance of quality of images. Proposed technique through the process of repeated partitioning process, the enhancement process maintained the effect of each gray level while extending the gray level of the image while retaining the simplicity of the algorithm and use weighted model work to increase brightness and preserving effect every gray level. Future application include photo obtained from satellite communication because satellite image distorted due to space interference and many reason else other applications

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