Contrast Enhancement using Completely Overlapped Uniformly Decrementing Sub-Block Histogram Equalization for Less Controlled Illumination Variation

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Abstract: *Illumination pre-processing is an inevitable step for a real-time automatic face recognition system in solving challenges related to lighting variation for recognizing the face images. This paper proposes a novel framework namely Completely Overlapped Uniformly Decrementing Sub-Block Histogram Equalization (COUDSHE) to normalize or pre-process the illumination deficient images. COUDSHE is based on the idea that efficiency of the pre-processing technique mainly depends on the framework for application of the technique on the affected image. The primary goal of this paper is to bring out a new strategy for localizing a Global Histogram Equalization (GHE) Technique to help it adapt to the local light condition of the image. The Mean Squared Error (MSE), Histogram Flatness Measure, Absolute Mean Brightness Error (AMBE) are the objective measures used to analysis the efficiency of the technique. Experimental Results reveal that COUDSHE has better performance on Heavy shadow images and half lit image than the existing techniques.*

Keywords: *Illumination pre-processing; global histogram equalization; localization; mean squared error; histogram flatness measure, absolute mean brightness error.*

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1. Introduction

One of the major challenge faced by automatic face recognition system is facial appearance variation due to effects of illumination variation. Changes in Illumination causes drastic variation between the same facial images acquired under different illumination effects. In a real time scenario, changes in illumination can be caused mainly due to two reasons. One is due to the Brightness in the light rays and other is due to the direction of illumination [12]. The effects of severe illumination variations are overexposed, heavy shadowed, half lit images and black lit images [4, 5]. It has been proved that large variation caused to the acquired image because of change in illumination resulted in large image difference than did varying the identity of the face [5, 15, 17, 19]. As a result the subsequent steps of image processing namely, face detection, face recognition fails drastically [7, 14, 15, 19].

There are many algorithms proposed for pre-processing images acquired with Illumination variations. Illumination pre-processing algorithms are broadly classified into three main categories namely principles of gray-level transformation, gradient or edge extraction and reflectance field estimation [5]. By a cross category comparison of three kinds of methods, it is specified that approaches based on gray-level transformation and reflectance field estimation usually preserve more facial features compared with gradient or edge extraction based methods [5].

Reflectance field estimation decomposes the image into large-scale and small-scale bands [5] where as Gray-level transformation is simple, efficient and yet an easy to understand technique. Histogram Equalization falls under the category of Gray level transformation.

Histogram equalization is an efficient, simple, commonly used technique [1, 2, 4, 21]. Histogram equalization technique is broadly classified into Global Histogram Equalization (GHE) and Local Histogram Equalization technique (LHE) [13]. Global histogram equalization uses the histogram information of the whole input image as its transformation function. As, a result the dynamic range of the image histogram is flattened and stretched and the overall contrast is improved [17]. The major drawbacks are it cannot adapt to local brightness of the input image and preserve the brightness of the original image [1, 21]. Local Histogram Equalization and Partially Overlapped Sub-Block Histogram Equalization (POSHE) are few of the methods proposed to localize and to overcome the challenges the global technique [6, 9, 11].

LHE also called block-overlapped histogram equalization is adaptive to local brightness changes and obtains a overall contrast regardless of the location of the input image [9]. In this method the computation complexity is very high. Despite this, LHE results in a over enhanced image.

POSHE was proposed to make the histogram equalization locally adaptive for higher contrast, and reduce computation complexity [9]. This method reduces the computational overhead in LHE by partially overlapping the sub-blocks yet localizing the global histogram technique.

This research work concentrates on proposing in a novel strategy for localizing histogram equalization technique for enhancing the illumination affected image. The proposed framework is Completely Overlapped Uniformly Decrementing Sub-Block Histogram Equalization (COUDSHE). Using COUDSHE the contrast of input image can be enhanced and brightness of the input image can be preserved. COUDSHE minimizes the computation complexity present in LHE and POSHE, despite of localizing the global technique.

2. Related Work

GHE is a image contrast enhancement technique used for pre-processing the image. GHE is commonly used technique because of its simplicity and high efficiency [8, 18, 20]. Its basic idea lies on mapping the gray levels based on the cumulative distribution function of the input gray levels obtained [3, 16]. Given an digital image X, gray scale values of the pixels ranges from [0, 255]. Let X_K denote the pixels with gray scale K [0, L-1] in image X. The probability of occurrence of gray level X_k in the image is given by

$$p(X_k) = \frac{n_i}{N} \tag{1}$$

where,

N stands for total number of pixel in an image.

n_i stands for the number of pixels having the intensity X_K.

Based on the probability distribution function (pdf) the cumulative distribution function (cdf) is defined

$$C(X_k) = \sum_{j=o}^{k} p(X_j) \tag{2}$$

where,

K varies from 0 to L-1.

Now the transformation function is given by

$$T(X_k) = X_0 + (X_{L-1} - X_0)C(X_k) \tag{3}$$

where,

$T(X_k)$ represents image after histogram equalization.

There are many drawbacks in the GHE. being a conventional histogram equalization technique it introduces a significant change in brightness of the image [3, 6]. The limitations are the presence of annoying artifacts and brightness of the image is not preserved. The Figure. 4-f shows the half lit image and histogram representation of an half lit image. Figure 4 summarizes the results (Pre-processed image and histogram) after the application of GHE on the half lit image.

Several extensions of GHE was developed to overcome the drawbacks of GHE. Brightness Preserving Bi-Histogram Equalization (BBHE) was proposed to preserve the original brightness of the image [3, 8, 10, 20, 21]. BBHE partitions the histogram of the original image into sub histograms using the mean brightness value and equalizes each sub-histogram independently using GHE. But mean of the input image used for partition the histograms did not guarantee maximum brightness preservation [3]. So Minimum Mean Brightness Error Bi-Histogram Equalization in Contrast Enhancement (MMBEBHE) was proposed. In this technique threshold for the mean which was used to partition the histogram was chosen in such a way that it results in minimum Absolute mean brightness error [3, 20]. All the aforementioned techniques use the global information to derive the global transformation function but it cannot adapt to local brightness.

In LHE, a window is defined, for that window histogram is computed and then histogram equalization function is determined for that window. The centre pixel of that window is equalized using equalization function obtained. The centre of window is moved to the adjacent pixel. The same procedure is repeated for each pixel in the input image. Histogram equalization has to be performed for all pixels in the entire image, hence the computational complexity is very high.

Partially overlapped sub block histogram equalization was proposed to reduced the computational complexity of LHE yet retain the local adaptability of LHE.

Steps for performing Partially overlapped Sub-block histogram Equalization [9]:

- *Step* 1: given an input image I, define an output image array of size equal to the input image.
- *Step* 2: Now define a sub-block of size mxn. Let the origin of the sub-block be the origin of the image.
- *Step* 3: perform histogram equalization on the whole sub-block, and accumulate the results in the output image array [9].
- *Step* 4: now move the sub block origin by horizontal step size. The step size can be half of the size of the block.
- *Step* 5: now, perform histogram equalization on the new region. Continue the above mentioned steps till the horizontal end of the image.
- *Step* 6: now, move the sub-block by vertical step size and repeat the application of histogram equalization.

- *Step* 7: Repeat these horizontal and vertical movement till the sub-block travels over the whole image plane.
- *Step* 8: Now average the intensity values for each pixels based on the number of times histogram equalization has been done.

Figure 1 illustrates the procedure adapted in POSHE. Suppose the image is composed of four partially overlapped sub-blocks as in Figure 1 and the step size is half of the sub-block size. The first sub-block considered comprises of regions R_1, R_2, R_4, and R_5. Histogram equalization is performed in this block. The Second sub-block considered comprises of regions R_2, R_3, R_5, and R_6. The Second sub-block considered overlaps the second part of the first sub-block. Now, histogram equalization is performed in this sub-block. The third sub-block considered is R_4, R_5, R_7 and R_8. Here again the Regions R_4 and R_5 is reconsidered along with R_7 and R_8. The sub regions R_1, R_3, R_7 and R_9 undergo histogram equalization once. Sub-regions R_2, R_4, R_6, and R_8 undergo histogram equalization only twice. The region R_5 is 4 times histogram equalized.

R_1	R_2	R_3
R_4	R_5	R_6
R_7	R_8	R_9

Figure 1. Partially overlapped sub-blocks.

The drawback of POSHE is blocking effect and implementation of the POSHE on half lit images fails to enhance the input image. The reason for the failure is it gives good results only in the middle part of the image, namely the regions R_2, R_5, R_8 but the regions like R_1, R_4, R_7 and R_3, R_6, R_9 are not equalized efficiently. The reason is that, POSHE overlaps only second half of the first block and first half of the second part of the image. So the equalization or normalization happens only in the regions R_2 ,R_5,R_8 will not affect the regions R_1, R_4, R_7 and R_3, R_6, R_9. There is no normalization of the gray level between the regions R_1, R_4, R_7 and R_3, R_6, R_9. Hence illumination pre-processing using POSHE does not normalize or enhance the input image symmetrically. For facial images, $R_1$and R_3 are symmetrical regions which requires to be normalized with respect to each other. Similarly regions R_4, R_6 and R_7, R_9 suffers for the same deficiency. The results after the application of the POSHE on half lit images are presented in the following Figure 4-h.

In the Figure 4-h the image pre-processed using POSHE has blocking effect. This blocking effect occurs due to change in the transformation function obtained for each sub-block [9]. The difference in the transformation between the adjacent blocks causes gray-level change at the boundaries. This gives rise to gray-level discontinuities which introduces blocking effect. To reduce the blocking effect Blocking Effect Reduction Filter (BERF) is used [9]. The procedure adapted to reduce the blocking effect brings in computation complexity. To reduce the effect of computational complexity and to localize the global technique COUDSHE is proposed.

3. Proposed Work

The proposed methodology brings out an unique framework to localize the global technique. The COUDSHE frame work reduces the computational complexity of LHE as in POSHE but overcomes the drawback of POSHE which suffers from equalizing the symmetrical image regions. This novel framework is proposed with three main perspectives:

1. To localize the global technique.
2. To enhance the image efficiently by adapting to the local brightness considering symmetrical regions.
3. To reduce the computation complexity associated with Local Histogram equalization and Removal of the Blocking effect.

Figure 2 shows the unique framework of COUDSHE. COUDSHE is performed on the four blocks which are completely overlapping on each other. In R_1 histogram equalization is done once, In R_2 HE is done twice, in R_3 HE is done thrice and in R_4 it is done 4 times.

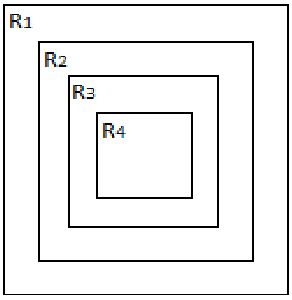


Figure 2. Completely overlapped Uniformly Decrementing Sub-Block Histogram Equalization (COUDSHE).

3.1. Procedure of COUDSHE is as Follows

- *Step* 1: define an output image array equal to the size of input image and set all the value to be zero.
- *Step* 2: perform Global Histogram Equalization for the whole image(whole block) and store the output to a temporary array of size equal to the input array.
- *Step* 3: now, reduce the size of the block uniformly on all four sides of the image. That is shift the origin of the image by increasing the horizontal step size and the vertical step size by a value of your choice. Similarly decrease the image's horizontal and vertical size by the same value opted in the previous step, now perform Global Histogram Equalization on the uniformly decremented block.
- *Step* 4: store the output to another temporary array size equal to the size of the input image in the corresponding image locations and pad zeros on the outer most region.

- *Step* 5: repeat the steps 3 again until the block size is minimal (your choice).
- *Step* 6: after decrementing block equalization is complete, add the each pixel value in the corresponding locations of temporary array and divide by the number of times they were equalized and store the average value in the output image array.

In Figure 2, consider the region R_4, HE is applied 4 times. Let the transformation function for histogram equalization on each block namely R_1, R_2, R_3, R_4 be denoted by $T_{R1}(X_k)$, $T_{R2}(X_k)$, $T_{R3}(X_k)$, $T_{R4}(X_k)$ respectively.

COUDSHE for region R_4 =1/4{ $T_{R1}(X_k)$ for the Image region overlapping with R_4 + $T_{R2}(X_k)$ for the Image region overlapping with R_4 + $T_{R3}(X_k)$ for the Image region overlapping with R_4 + $T_{R4}(X_k)$ } (4)

3.2. Analysis of COUDSHE

COUDSHE initially considers the whole image. In the next step it considers a sub-block whose origin is diagonally below the origin of the input image. The origin of the sub-block is selected by defining a incrementing size d which changes the origin (0, 0) to (d, d). Subsequently decrease the size of the image from M,N to M-d, N-d. Perform histogram equalization on the new region and store it in a temporary array. Continue these steps till we reach a minimal size. If the value of *d* is less, then the number of completely overlapping sub-blocks considered will be more. If the value of d is huge the number of sub-blocks considered will be less. So if n denotes the number of sub-blocks and d denotes the incrementing size then *d* is inversely proportional to *n*

$$d = \frac{1}{n} \quad (5)$$

In General for any value of *d* and *n* COUDSHE for inner most region R_n=1/n{ $T_{R1}(X_k)$ for image region overlapping with n+ $T_{R2}(X_k)$ for the image region overlapping with n+ $T_{R3}(X_k)$ for the image region overlapping with

$$n+.......+T_{Rn}(X_k) \quad (6)$$

Image Portion of R_1 overlapping with R_n is given by the image coordinates:

$$Origin = (n-1)*d, (n-1)*d \quad (7)$$

$$Imagesize = (M-(n-1)*d), N-(n-1)*d) \quad (8)$$

$\|^{ly}$ Image Portion of R_2 overlapping with R_n is given by the image coordinates:

$$Origin = (n-2)*d, (n-2)*d \quad (9)$$

$$Imagesize = (M-(n-2)*d), N-(n-2)*d) \quad (10)$$

3.3. Computational Complexity Analysis

When applying LHE, for a 640x480 pixel image, histogram equalization must be performed 307200 times. When applying POSHE, for a 640x480 pixel image, sub block size and step size must be defined before estimating the computational complexity of POSHE. Suppose the sub block size is defined to be 160x120 and step size is half the size of the sub block then histogram equalization must be performed 7x7= 49 times. In COUDSHE, for an image of size 640x480, and number of sub block be 7, then histogram equalization is performed 7 times. POSHE computational cost must also include BERF cost, where as COUDSHE does not include any BERF cost.

4. Experimental Results and Discussions

To reveal the efficiency of the proposed method COUDSHE, the result of COUDSHE is compared with GHE and POSHE for illumination pre-processing. Images considered are one subject's image under varying illumination (see Figure 3).

Figures 4-b shows a heavy shadowed image and it's histogram representation. The resultant images after pre-processing the heavy shadowed image using GHE, POSHE and COUDSHE and their respective histograms are shown in Figures 4-c, 4-d and 4-e. The next image considered is half lit image. Figure 4-f shows the half lit image and its histograms before pre-processing. The resultant images after pre-processing the half lit image using GHE, POSHE and COUDSHE and their respective histograms are shown in Figures 4-g, 4-h, and 4-i. Lastly, we have considered a black lit image shown in Figures 4-j. The resultant images after pre-processing the black lit image using GHE, POSHE and COUDSHE and their respective histograms are shown in Figures 4-k, 4-l, and 4-m respectively.

Figure 3. shows the images of the same person taken under different illumination conditions.

The histograms of the images pre-processed using COUDSHE has better spread between the gray level [0-255] compared to the histograms of the image pre-processed using other techniques. Higher the spread better is the contrast ratio. The Quality measure used to check the competence of the proposed technique are Mean Squared Error (MSE), Histogram Flatness (σ) and Absolute Mean Brightness Error (AMBE).

MSE of an image measures the difference between the histograms of the image taken under proper lightening condition and illumination pre - processed image. The Error rate between the image taken under proper lightening condition and illumination pre-processed image is given by MSE:

$$MSE = \frac{\sum\left(h^{o}{}_{i} - h^{p}{}_{i}\right)^{2}}{L} \tag{11}$$

where,
$h^o{}_i$ th stands for the size of the ith bin of the image's histogram taken under proper lightening condition and $h^p{}_i$ th stands for the size of the ith bin of the image preprocessed using various pre- processing techniques.

The Histogram flatness value(σ) measures the main objective of histogram equalization. The main objective of GHE is to produce a perfectly flat histogram which uses equally the entire dynamic range of image intensities. A perfectly flat histogram which uses equally the entire dynamic range of image intensities results in a high contrast image. Smaller value of σ indicates a flatter histogram.

$$\sigma = \sum \frac{\left(h_i - \mu_h\right)^2}{D} \tag{12}$$

where,
h_i is the size of the i^{th} bin of the image histogram,
μ_h is the mean histogram bin size and D is the number of image intensities.

AMBE is defined to be the absolute difference between the mean of the original image taken under various illumination condition (input image) and illumination pre-processed image (output image) as stated below

$$\text{AMBE} = |\, E(X) - E(Y) | \tag{13}$$

where,
X is the input image
Y is the output image

Lower AMBE value implies better the brightness preservation.

Table 1 clearly shows that histogram flatness measure. Flatness measure of heavy shadow image after processing using COUDSHE is remarkably lessercompared to other pre-processing techniques. For half-lit image, flatness measure obtained after preprocessing using COUDSHE is lesser than flatness measure of images processed using POSHE and GHE. With respect to black lit image GHE and POSHE result in a has better flatness measure compared to COUDSHE.

The MSE tabulated in Table 2. Illumination affected Images pre-processed using COUDSHE has the minimum error rate compared to images pre-processed using GHE and POSHE.

Table 3 tabulates the AMBE values of the images preprocessed using various illumination preprocessing techniques. For a heavy shadow image, illumination preprocessed using COUDSHE has a lesser AMBE value compared to POSHE, for a half lit image COUDSHE performs in par with POSHE and GHE. But for a black lit image POSHE performs better than the proposed frame work.

Table 1. Histogram Flatness Values obtained after pre-processing Image 1 in Figure 4-b, Image 2 in Figure 4-f, Image 3 in Figure 4-j using GHE, POSHE, COUDSHE.

Method	**Image 1**(Heavy shadowed image)	**Image 2**(Half lit image)	**Image 3(B**lack lit image)
GHE	52.8867	72.7344	74.6630
POSHE	87.4150	72.7744	57.6200
COUDSHE	44.8846	72.6630	98.2070

Table 2. Mean Squared Error obtained after pre-processing Image1 in Figure 4-b, Image 2 in Figure 4-f, Image 3 in Figure 4-j using GHE, POSHE, COUDSHE.

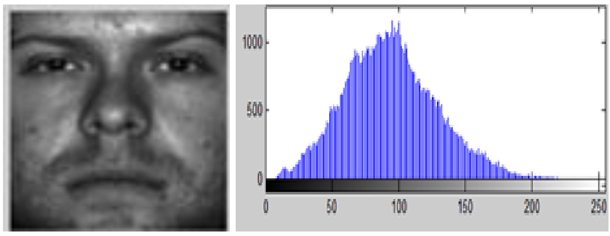
Method	**Image 1((**Heavy shadowed image)	**Image 2((**Half lit image)	**Image 3((B**lack lit image)
GHE	7.4504e+005	1.1541e+006	2.0406e+006
POSHE	2.8540e+005	3.9658e+005	5.7319e+005
COUDSHE	2.8453e+005	3.5750e+005	5.5895e+005

Table 3. AMBE values obtained after preprocessing Image1 in Figure 4-b, Image 2 in Figure 4-f, Image 3 in Figure 4-j using GHE, POSHE, COUDSHE.

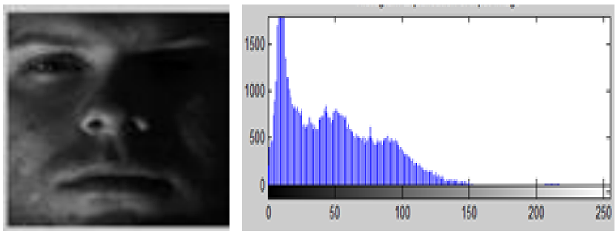
Method	**Image 1((**Heavy shadowed image)	**Image 2((**Half lit image)	**Image 3((B**lack lit image)
GHE	74.0436	62.5264	88.5388
POSHE	80.0345	62.8558	86.9833
COUDSHE	73.9289	62.9773	95.3167

5. Conclusions

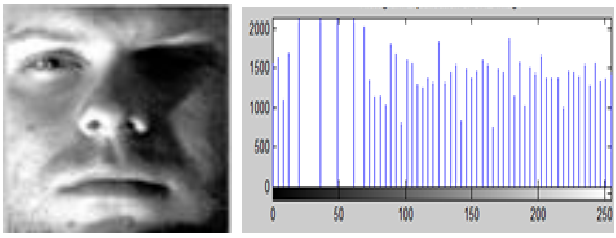
The main objective of this research work is to propose a novel framework to localize Global Histogram Equalization. Completely overlapping uniformly decrementing sub block histogram equalization was proposed to overcome the drawbacks of LHE and POSHE. COUDSHE provides a framework for localizing the global technique and normalizes the symmetrical regions of an image efficiently. The efficiency of COUDSHE framework for processing heavy shadow image and half lit image is proved to be better compared to GHE and POSHE.



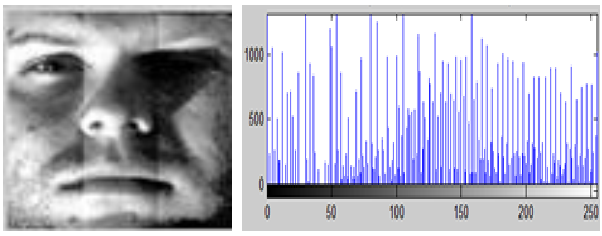
a) Image taken under good illumination condition and its histogram.



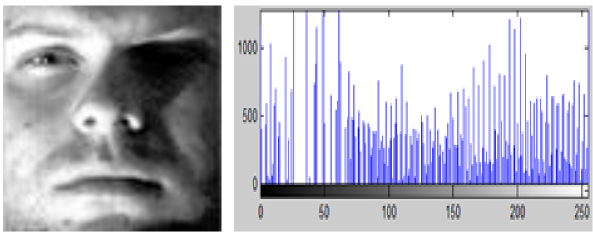
b) Image 1(Heavy shadowed image) and its histogram.



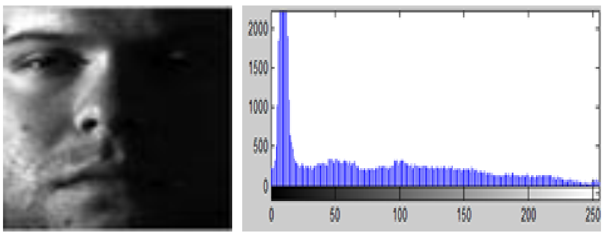
c) Resultant image1 after GHE and its histogram.



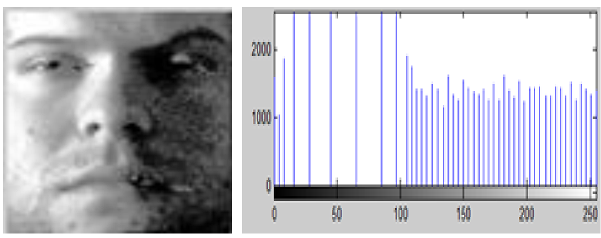
d) Resultant image1 after POSHE and its histogram.



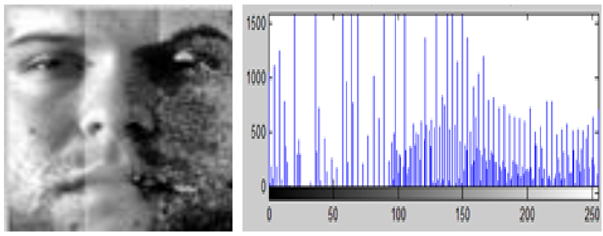
e) Resultant image1 after COUDSHE and its histogram.



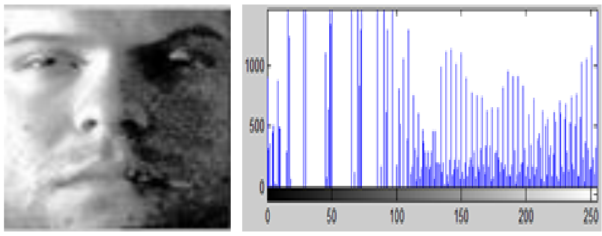
f) Image2 (Half lit image) and its histogram.



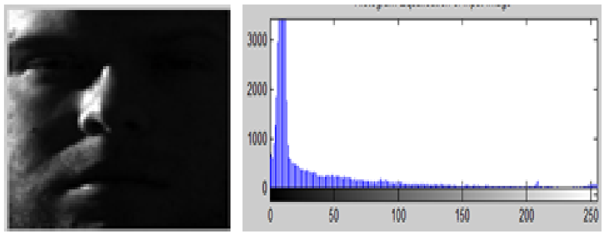
g) Resultant image2 after GHE and its histogram.



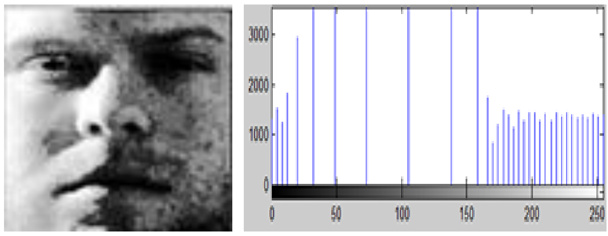
h) Resultant image2 after POSHE and its histogram.



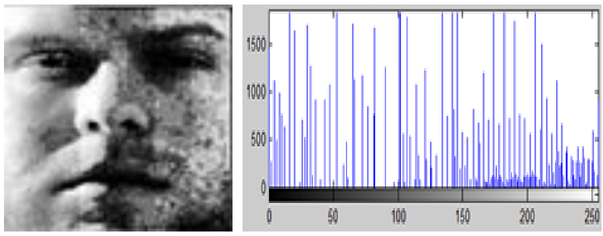
i) Resultant image2 after COUDSHE and its histogram.



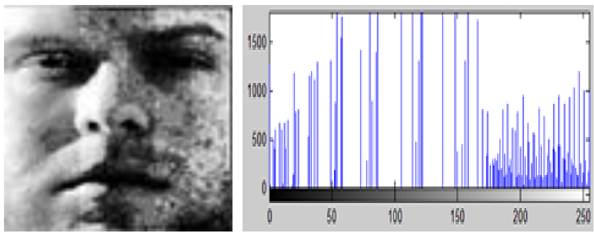
j) Image 3(black lit image) and its histogram.



k) Resultant image3 after GHE and its histogram.



l) Resultant image3 after POSHE and its histogram.



m) Resultant image3 after COUDSHE and its histogram.

Figure 4. shows the various kinds of illumination affected images and resultant images after preprocessing them using GHE, POSHE,COUDSHE.

In terms of computational complexity, histogram flatness measure, AMBE value and MSE.

Implementing other improvised methods of GHE like Brightness preserving Bi-Histogram Equalization (BHE), Dualistic sub-image Histogram Equalization (DSIHE), Recursive mean separate histogram equalization (RMSHE) in this frame work will give improved results. The simplicity of COUDSHE leverage the implementation of this technique in electronic products.

References

[1] Aedla R., Dwarakish G., and Reddy V., "A Comparative Analysis of Histogram Equalization based Techniques for Contrast Enhancement and Brightness Preserving," *International Journal of Signal Processing, Image Processing and Pattern Recognition*, vol. 6, no. 5, pp. 353-366, 2013.

[2] Agarwal T., Tiwari M., and Lamba S., "Modified Histogram based Contrast Enhancement using Homomorphic Filtering for Medical Images," *in Proceedings of Advance Computing Conference*, Gurgaon, pp. 964-968, 2014.

[3] Chen S. and Ramli A., "Minimum Mean Brightness Error Bi-Histogram Equalization in Contrast Enhancement," *IEEE Transactions on Consumer Electronics* vol. 49, no. 4, pp. 1310-1319, 2003.

[4] Gonzalez R. and Woods R., *Digital Image Processing*, MA: Addison-Wesley, 1992.

[5] Han H., Shan S., Chen X., and Gao W., "A Comparative Study on Illumination Preprocessing in Face Recognition," *Pattern Recognition*, vol. 46, no. 6, pp. 1691-1699, 2013.

[6] Ibrahim H. and Kong N., "Brightness Preserving Dynamic Histogram Equalization for Image Contrast Enhancement," *IEEE Transactions on Consumer Electronics*, vol. 53, no. 4, pp. 1752-1758, 2007.

[7] Juefei-Xu F. and Savvides M., "Encoding and Decoding Local Binary Patterns for Harsh Face Illumination Normalization," *in Proceedings of International Conference Image Processing IEEE Conference*, Quebec City, pp. 3220-3224, 2015.

[8] Kabir H., Wadud A., and Chae O., "Brightness Preserving Image Contrast Enhancement Using Weighted Mixture Global and Local Transformation Functions," *The International Arab Journal of Information Technology*, vol. 7, no. 4, pp. 403-410, 2010.

[9] Kim J., Kim L., and Hwang S., "An Advanced Contrast Enhancement Using Partially Overlapped Sub-Block Histogram Equalization," *IEEE Transactions on Circuits and Systems for Video Technology*, vol. 11, no. 4, pp. 475-484, 2001.

[10] Kim Y., "Contrast Enhancement Using Brightness Preserving Bi-Histogram Equalization," *IEEE Transaction Consumer Electronics*, vol. 43, no. 1, pp. 1-8, 1997.

[11] Kim Y., Keun T., Paik J., and Kang B., "Contrast Enhancement System Using Spatially Adaptive Histogram Equalization with Temporal Filters," *IEEE Transactions Consumer Electronics*, vol. 44, no. 1, pp. 82-87, 1998.

[12] Langer M. and Zucker S., *Computer Vision-ECCV'94*, Springer, 1994.

[13] Lee C., Lee C., and Kim C., "Contrast Enhancement Based on Layered Difference Representation of 2D Histograms," *IEEE Transactions on Image Processing*, vol. 22, no. 12, pp. 5372-5384, 2013.

[14] Liu C., Chen W., Han H., and Shan S.**,** "Effects of Image Preprocessing on Face Matching and Recognition in Human Observers," *Applied Cognitive Psychology*, vol. 27, no. 6, pp. 718-724, 2013.

[15] Marsico M., Nappi M., and Riccio D., Wechsler H., "Robust Face Recognition for Uncontrolled Pose and Illumination Changes," *IEEE Transactions on Systems, Man and Cybernetics* vol. 43, no. 1, pp. 149-163, 2013.

[16] Ooi C. and Isa N., "Adaptive Contrast Enhancement Methods with Brightness Preserving," *IEEE Transactions on Consumer Electronics*, vol. 56, no. 4, pp. 2543-2551, 2001.

[17] Rabbani M. and Chellappan C., "An Effective Approach to Frontal Face Recognition Using Distance Measures," *Asian Journal of Information Technology*, vol. 4, no. 12, pp. 1110-1115, 2005.

[18] Wang Y., and Chen Q., and Zhang B., "Image Enhancement Based on Equal Area Dualistic Sub-Image Histogram Equalization Method," *IEEE Transactions on Consumer Electronics*, vol. 45, no. 1, pp. 68-75, 1999.

[19] Xie X., Zheng W., Lai J., Yuen P., and Suen C., "Normalization of Face Illumination Based on Large-and Small-Scale Features," *IEEE Transactions on Image Processing*, vol. 20, no. 7, pp. 1807-1821, 2011.

[20] Zuo C., Chen Q., Sui X., and Ren J., "Brightness Preserving Image Contrast Enhancement using Spatially Weighted Histogram Equalization," *The International Arab Journal of Information Technology*, vol. 11, no. 1, pp. 25-32, 2014.

[21] Zuo C., Chen Q., and Sui X., "Range Limited Bi-Histogram Equalization for Image Contrast Enhancement," *Optik*, vol. 124, no. 5, pp. 425-443, 2013.

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