Automatic Contrast Enhancement Images Acquired by Security, Surveillance, and Situational Awareness Systems Using Two Recent Histogram Based Techniques

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Abstract
Military operations in urban terrain (MOUT) scenarios also call for distributed information gathering and processing capabilities. Video cameras abound in civilian life wherever security is of interest (e.g. in commerce, transportation, education, entertainment and so forth). The viability of distributed security and surveillance capabilities is enabled by the advent of low-cost cameras, computers, and networking technology (both wired and wireless). Sometime the images captured by these cameras are poor lighting conditions (e.g. photograph at night, or carry the situation facing toward the light). Due to these constrained imaging conditions, images acquired by these systems may exhibit low contrast. The goal of this effort is applied two recent histogram based techniques to these images and ascertains which of these techniques are better suited across a variety of images from different sensors and having varying characteristics. The recent techniques are low-complexity histogram modification technique (LCHM) and weighted thresholded histogram equalization technique (WTHE). Based on the visual quality and using Mean Square Error (MSE), Absolute Mean Brightness Error (AMBE) and the discrete entropy (H), are the most common measures of picture quality in image processing, we conclude that the WTHE technique variant of the LCHM technique and it applied for automatic contrast enhancement across a wide variety of images acquired by security, surveillance, and situational awareness systems.

Key Words
Color images, contrast enhancement, entropy, histogram equalization, histogram modification.

1. Introduction

In recent years, the need for distributed surveillance systems has emerged in applications ranging from homeland defense to modern network centric warfare concepts. Sometimes images obtained from these systems lack in contrast and brightness because of the limitations of imaging sub systems and illumination conditions while capturing image. In image enhancement, the goal is to accentuate certain image features for subsequent analysis or for image display [1, 2]. Image contrast enhancement plays a crucial role in image processing applications, such as digital photography, military, security, and scientific visualization [3, 4]. The techniques for contrast enhancement include gray-level transformation based techniques (viz., logarithm transformation, power-law transformation, piecewise-linear transformation, etc.) and histogram processing techniques (viz., histogram equalization (HE), histogram specification, etc.)[5]. Conventionally, the contrast enhancement is manually performed using spatial domain methods, as there is generally a necessity to select specific parameters for enhancement. Therefore, conventional contrast enhancement techniques have an inherent inability for automation and also cannot be applied for broad variety of images. Moreover, if the images are originally of low contrast - like those pertaining to satellite images (especially of the oceans), aerial images and images acquired by Security, Surveillance, and Situational Awareness Systems – then additional limitations which arise out of employing the conventional contrast enhancement techniques include the washed out effect, amplification of background noise, subjective manual manipulation, nonpreservation of brightness and the inability to discern localized intensity changes.

Various methods have been proposed for limiting the level of enhancement, most of which are obtained through modifications on HE. Recent studies [3, 4] stress on the importance enhancement variance of images without most that limitations and necessity of having automatic methods for contrast enhancement and suggest the low-complexity histogram modification LCHM technique method for automatic contrast enhancement. In the LCHM technique based technique, the histogram is used to deals with histogram spikes, performs black and white stretching, and adjusts the level of enhancement adaptively [3].

Another recent method proposed by Wang and Ward [6] suggests modifying the image histogram by weighting and thresholding before histogram equalization. The weighting and thresholding is performed by clamping the original histogram at an upper threshold and at a lower threshold, and transforming all the values between the upper and lower thresholds using a normalized power law function with index.

All recent previous techniques are operating on image pixels and result in the generation of uniform histogram by

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avoiding under or over contrast problems. Therefore, in this paper we explore the efficacy that's techniques for contrast enhancement on a variety (gray scale as well as color) of images. We are also interested to know whether any one specific technique can be used for automatic contrast enhancement of images from a wide variety of sensors and therefore decided to compare that's techniques for contrast enhancement by considering some low contrast test images obtained from different sensors having varied characteristics. The criteria employed for performance analysis are based on the visual quality and the quantitative measures as it the accepted tools, for comparison across various techniques.

In the next section, The LCHM contrast enhancement technique is explained. The WTHE technique is explained in sections 3. Simulation results and discussions are presented in Section 4. Finally, the conclusion is provided in Section 5.

2. The LCHM technique

In this section, the technique of the low-complexity histogram modification LCHM [3] is described as follows:

A. Histogram computation

For contrast enhancement using this technique, first and foremost, the histogram should be modified in such a way that the modified histogram, ĥ, represents the conditional probability of a pixel, given that it has a contrast with its neighbors (denoted by C). That is, ĥ[i] = P[i|C] , where P[i|C] denotes the probability of a pixel having gray-level given the event C. Performing histogram equalization on ĥ rather than h(original histogram). However, one can simply obtain P[i|C] by counting only those pixels that have contrast, so the modified histogram have not large values of bin. To obtain the histogram, the local variation of each pixel can be used to decide if a pixel has sufficient contrast with its neighbors.

B. Adjusting the level of enhancement

Black and white (B&W) stretching method is applied to the modified histogram, ĥ, when obtained it in the previous section. The gray-level range for B&W stretching is [0, b] and [w, 255], respectively. The modified histogram is the input histogram, hi, to the B & W stretching then the histogram modified becomes as the following:

$$\tilde{h}[n]=\begin{cases} k^{*}h_i[n]+(1-k^{*})u & b<n<w \\ 1/(1+\alpha)[k^{*}h_i[n]+(1-k^{*})u] & otherwise \end{cases} \quad (1)$$

where n, K* are the intensity level and the contribution of the input histogram, respectively, and α is a parameter varies over [0, ∞]. To ensure that hi and u have the same normalization, u is obtained using the number of pixels that are included in this histogram.

3. The WTHE contrast enhancement technique

The histogram of an image with intensity levels in the range [0, L – 1] is a discrete function h(r(k)) = n(k), where r(k) is the kth intensity level and nk is the number of pixels in the image with intensity r(k). It is common practice to normalize a histogram by dividing each of its components by the total number of pixels in the image, denoted by product MN, where, as usual, M and N are the row and column dimensions of the image. Thus, a normalized histogram is given by P(r(k)) = n(k) /MN, for k = 0, 1, 2, …, L – 1. Loosely speaking, P(r(k)) is an estimate of the probability of occurrence of intensity level r(k) in an image [7]. Suppose that an input image I with intensity levels in the range [0, L – 1] and its histogram was calculated. The weighted thresholded histogram equalization (WTHE) enhancement method performs HE based on a modified histogram [6]. To modified histogram each original probability density value P(r(k)) is replaced by a weighted and thresholded PDF value Pwt(r(k)). Pwt(r(k)) is obtained by applying a transformation function T(P(r(k))) to P(r(k)), such that

$$p_{wt}(r(k))=T(P(r(k)))=\begin{cases} P_u & if\ P(r(k))>P_u \\ \left(\frac{P(r(k))-P_l}{P_u-P_l}\right)^{\gamma}\times P_u & if\ P_l\le P(r(k))\le P_u \\ 0 & if\ P(r(k))<P_l \end{cases} \quad (2)$$

for k = 0, 1, 2, ..., L – 1, The transformation function T(P (r(k))) clamps the original PDF at an upper threshold Pu and at a lower threshold Pl, and transforms all values between the upper and lower thresholds using a normalized power law function with index γ >0.

After the weighted thresholded PDF is obtained from equation (2), the transformation function using HE can be applying on the modified histogram as followed [1, 7]:

$$T_{HE}(r(k)) = (L-1)\sum_{j=0}^{k} p_{wt}(r(j)) \quad (3)$$

4. Results and Discussion

Assessment of image enhancement is desirable to have a subjective assessment approach to compare contrast enhancement techniques. In addition, an objective assessment is included, there are some metrics used in the literature that approximate an average contrast in the image based on some measures. Hence, we will use the following quantitative measures: The Mean Square Error (MSE), Absolute Mean Brightness Error (AMBE) and the discrete entropy (H)[8, 9, 10]. All techniques have successfully tested on a variety of test images. Only, a few of the results are shown in this paper.

A. Subjective Assessment

1. Gray-Scale Images: Fig.1 and Fig.2 show the original test images and their corresponding contrast enhanced images using LCHM and WTHE. The LCHM technique is compared with the WTHE technique and show similar visual quality on many of the images we tested. However, that is not always the case. Usually, histogram equalized images result in the best utilization of the dynamic range of the pixel values for maximum contrast. The LCHM and WTHE techniques also offer a controllability of the contrast enhancement.

Since the histogram of the LCHM is formed from the conditional probability, it does not have histogram spikes resulting from uniform regions; hence, the LCHM does not produce artifacts as conventional contrast enhancement techniques. The WTHE technique, on the other hand, thresholds high and low bin values to prevent its undesired effect and offers more controllability of the contrast enhancement than the LCHM. The LCHM method does not improve the natural-look of the image substantially compared to the WTHE technique.

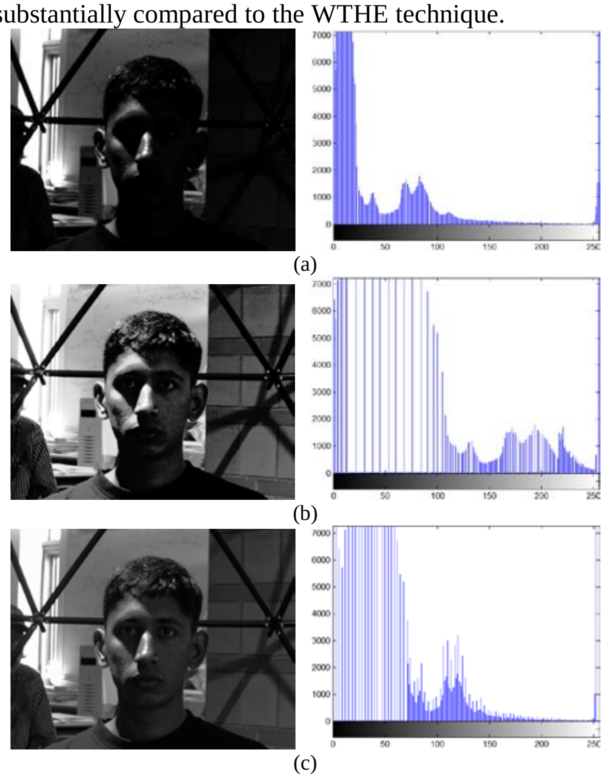

Fig.1. Results for image face. (a) Original image and histogram of it, (b) enhanced image obtained using the LCHM and histogram of it, (c) enhanced image obtained using WTHE and histogram of it.

Fig. 1(b) and Fig. 2(b) are the enhanced images and histograms of it, obtained using the LCHM of Figs. 1(a), 2(a). The contrast of the images is maximized at the expense of the amplified noise, and image artifacts. The resulting artifacts in the images are mostly in the left of the mane face, which is washed out because changing suddenly to the very bright regions. WTHE reduces the effect of LCHM. Hence, the contrast enhanced images obtained by the WTHE method are visually more pleasing than LCHM. However the LCHM and WTHE methods mapping in a stretching of a very narrow region into a wider region and vice as shown in the histogram of the original images and enhanced images; In Fig.1 range of [0, 24] is getting mapped to [0 112] in LCHM technique, [0, 75] in WTHE, and range of [120, 255] is getting mapped to [220 255], [140, 255] respectively. In Fig.2 range of [0, 20] is getting mapped to [0 98] in LCHM technique, [0, 78] in WTHE, and range of [150, 255] is getting mapped to [240 255], [150, 255] respectively. The mapping functions for LCHM are mapping dark pixels values into very bright pixel values. This is caused by the amplitudes histogram components in this type of images are very high at some location, spikes, on the gray scale and very small in the rest of the gray scale. Therefore the resulting images Fig.1 (c) and Fig.2(c) are not as visually pleasing as Fig. 1(b) and Fig. 2(b). The mapping function in the WTHE technique is less steeping from the other technique, so the resulting image is more natural-look.

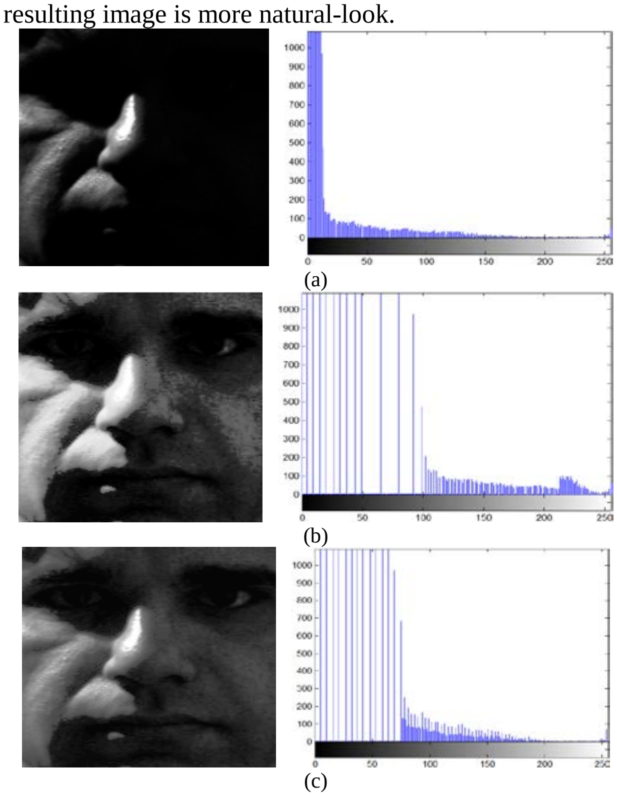

Fig.2. Results for image face. (a) Original image and histogram of it, (b) enhanced image obtained using the LCHM and histogram of it, (c) enhanced image obtained using WTHE and histogram of it.

2. Color Images: Contrast enhancement can be easily extended to color images. The most obvious way to extend the gray-scale contrast enhancement to color images is to apply the method to luminance component only and to preserve the chrominance components. One can also multiply the chrominance values with the ratio of their input and output luminance values to preserve the hue. Two examples using color images are given in Fig. 3 and Fig. 4.

Fig. 3(b) and Fig. 4(b) are the histogram equalized images of Figs. 3(a) and 4(a) using LCHM technique. These images have nonuniform illumination. This becomes apparent with histogram corresponding that's images. LCHM as it stretches the histogram to increase the contrast. WTHE result is similar the image result using LCHM as visual as shown in Figs. 3(c) and 4(c). Therefore the LCHM and WTHE are natural in all color images and it's very important to enhance some images, because it's automatic technique.

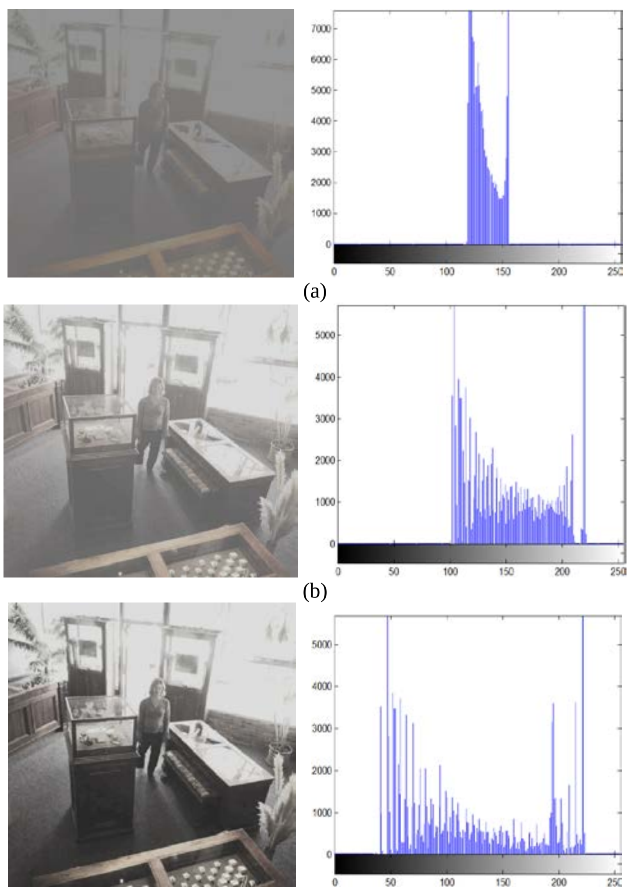

Fig.3. Results for image mugger. (a) Original image and histogram of it, (b) enhanced image obtained using the LCHM and histogram of it, (c) enhanced image obtained using WTHE and histogram of it.

B. Objective Assessment

Computed quantitative measures MSE, AMBE and H listed in Table 1 supplement the visual assessment presented earlier. Comparison of MSE and AMBE values shows that the WTHE technique outperforms the LCHM in all images because lower MSE and AMBE values indicates that the brightness is better preserved and greater images quality. Comparison of H values show that the WTHE technique performs similar to LCHM. Normally, one would expect WTHE to give higher discrete entropy value as HE results in more uniform histogram distribution. However, WTHE results in bin grouping and this decreases the H value.

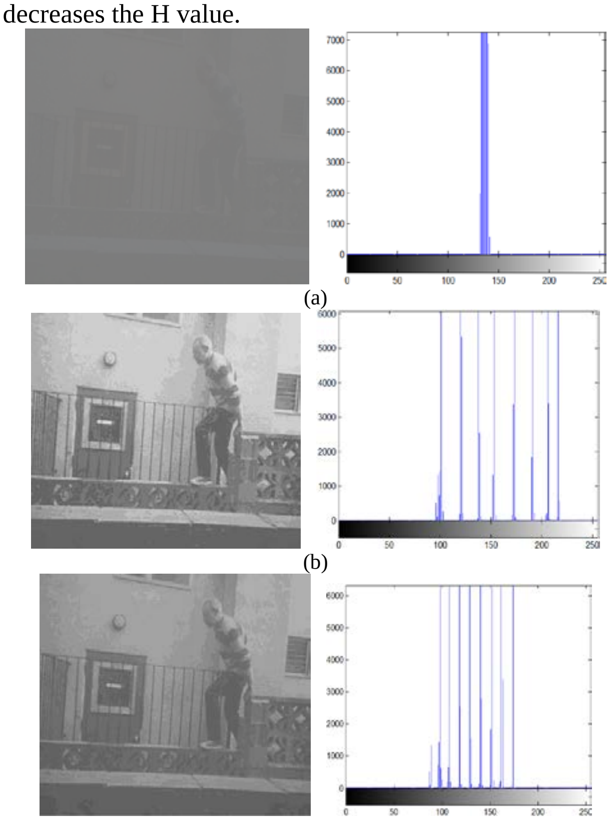

Fig.4. Results for image mugger. (a) Original image and histogram of it, (b) enhanced image obtained using the LCHM and histogram of it, (c) enhanced image obtained using WTHE and histogram of it.

Table 1: The MSE, AMBE and H values of the images in Figs.1, 2, 3 and 4.

		Fig. 1	**Fig. 2**	**Fig. 3**	**Fig. 4**
MSE	*WTHE*	$6.04*10^3$	606.6	$1.5*10^3$	$1.5*10^3$
	LCHM	$2.51*10^4$	$1.4*10^3$	$4.73*10^3$	$4.9*10^3$
AMBE	*WTHE*	0.107	0.130	0.008	0.021
	LCHM	0.185	0.169	0.096	0.077
H	***Original***	6.208	5.294	4.582	2.997
	WTHE	6.052	5.164	6.343	3.761
	LCHM	6.050	5.196	5.968	3.790

5. conclusion

The low-complexity histogram modification technique (LCHM) and weighted thresholded histogram equalization (WTHE) technique can be applied to a variety low-contrast images acquired by security, surveillance, and situational awareness systems to automatic enhanced these images. LCHM and WTHE were often capable to finding image information hidden in darkness, very easy and very quickly techniques. LCHM produced a much higher quality image. But it cannot fulfill certain special application purposes, such as that the amplitudes histogram components in the image are very high at some location, spikes, on the gray scale and very small in the rest of the gray scale. The WTHE technique is enhanced these types of images. Therefore we infer that the WTHE technique variant of the LCHM technique can be implemented for full automation across a broad variety of low-contrast images.

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References

[1] Rafael C. Gonzalez and Richard E. Woods, Digital Image Processing (3rd Edition), Prentice Hall, August 2008.
[2] C.G.Relf, Image Acquisition and Processing with LabVIEW: North Mopac Expressway Austin, USA: National Instruments, ni.com, 2004.
[3] Q. Wang and R. K. Ward, “A Histogram Modification Framework and Its Application for Image Contrast Enhancement,” IEEE Trans. Image. Process., vol. 18, no. 9, pp. 1921–1935, Sept 2009.
[4] Ismail A. Humied, Fatma E.Z. Abou-Chadi and Magdy Z. Rashad, “A new combined technique for automatic contrast enhancement of digital images”, Egypt Inform J 2012.
[5] FRANK Y. SHIH J, Image Processing and Pattern Recognition Fundamentals and Techniques, the Institute of Electrical and Electronics Engineers, Inc, Hoboken, New Jersey- Canada, Wiley and Sons, 2010.
[6] Q. Wang and R. K. Ward, “Fast image/video contrast enhancement based on weighted thresholded histogram equalization,” IEEE Trans. Consum. Electron., vol. 53, no. 2, pp. 757–764, May 2007.
[7] K. S. Thyagarajan, Digital Image Processing with Application to Digital Cinema, Focal Press, 2006.
[8] A. Beghdadi and A. L. Négrate, “Contrast enhancement technique based on local detection of edges,” Comput. Vis, Graph., Image Process., vol. 46, no. 2, pp. 162–174, May 1989.
[9] S.-D. Chen and A. Ramli, “Minimum mean brightness error bi-histogram equalization in contrast enhancement,” IEEE Trans. Consum. Electron., vol. 49, no. 4, pp. 1310–1319, Apr. 2003.
[10] S. Agaian, K. Panetta, and A. Grigoryan, “Transform-based image enhancement algorithms with performance measure,” IEEE Trans. Image Process., vol. 10, no. 3, pp. 367–382, Mar. 2001.

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