An Image Contrast Enhancement Method Using Brightness Preserving on the Linear Approximation CDF

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Abstract

In this paper, we have proposed the contrast control method using brightness preserving on the FPD(Flat Panel Display). *The proposed algorithms consist of three blocks: the contrast enhancement, the white-level-expander, and the black-level-expander. The proposed method has employed probability density function in order to control the brightness of the image changed extremely. In order for real-time processing, we have calculated cumulative density function using the linear approximation method. The image histogram and image quality were compared with the conventional image enhancement algorithms. The proposed methods have been used in display devices that need image enhancement such as LCD TV, PDP, and FPD.*

1. Introduction

Today, an industrial development of information and telecommunication replaces a conventional CRT(cathode ray tube) with high-resolution FPD(flat panel display) since CRT is much more bulky and dissipates larger power than the FPD. The main advantage of FPD includes lightweight, thinness, high-resolution, and low-power operation.

Generally, there are utilized contrast enhancement, edge enhancement, and noise reduction as the means of image enhancement. Among those techniques, this paper is concerned with contrast enhancement of image data. It is well known that histogram equalization produces maximally contrast enhanced image. However, the resulting image is far from a natural one, and furthermore, the extent of enhancement is not controllable. In addition to these drawbacks, the enhancement scheme based on the histogram of an image is very expensive and time consuming[1,2,3,4].

Already, many algorithms for image enhancement are proposed. In [5], as an effort to achieve natural contrast enhancement by preserving the brightness of the original image, bi-histogram equalization(BHE) method has been proposed. By using the BHE, overall brightness of the input image can be preserved. However, just brightness preservation doesn't mean preserving naturalness of the original image. Furthermore, this method still has no means to control the extent of enhancement while the controllability is required in many flat panel display applications. In another method[6], the contrast enhancement utilizes simplified histogram information obtained by the piecewise linear approximation to attain the controllability. However, the method is not control the brightness of the image changed extremely.

In this paper, we describe an image enhancement algorithm that can be improvement image quality, which uses probability density function in order to control the brightness of the image changed extremely. In order to real-time processing, we have calculated cumulative density function(CDF) using the linear approximation method. For effective processing of the proposed algorithm, we have utilized the sample value of CDF and barrel shift method. The contrast is not optimum, and modifications of the contrast of the processed image may not produce an improvement. In this case a BLE or WLE enhances the contrast of the image.

This paper is organized as follows. We describe the proposed enhancement algorithm. The architecture for proposed scheme is presented in section II. In section III, experimental results for various contrast enhancement effects are given. Finally, conclusion and future works are mentioned in section IV.

2. THE PROPOSED ALGORITHM

2.1 CDF Calculator Block By Linear Approximation

The transfer function requires complicated hardware and computing time[4]. The reason is due to calculating CDF. To obtain histogram information form an image of L gray levels, it is needed to count the number of pixel for every gray level. Thus L storages are required to store the count values. In order to reduced hardware requirement and computing time, we have proposed linear approximation CDF scheme. To obtain approximation CDF, We define CDF values at sampling point. The values of CDF at sampling point define as

$$CDF_{sample}(X_k) = \sum_{j=0}^{k} X_j \qquad (1)$$

for, $k \in \{\frac{L}{4}, \frac{L}{2}, \frac{3L}{4}, L-1\}$, $j = 0,1,..,L-1$ where $CDF_{sample}(X_k)$ represent the total sum of input image X_k. Figure 1 shows values of CDF at sample point k. In the case of 8-bit image, L=255, the value of each $CDF_{sample}(X_k)$ have the following

$$0 \le CDF_{sample}(X_{64}) \le CDF_{sample}(X_{128}) \le CDF_{sample}(X_{192}) \le 255$$

The CDF values at the sampling points determine the transfer function in the approximation scheme. Thus the proposed method can be realized with much less operation.

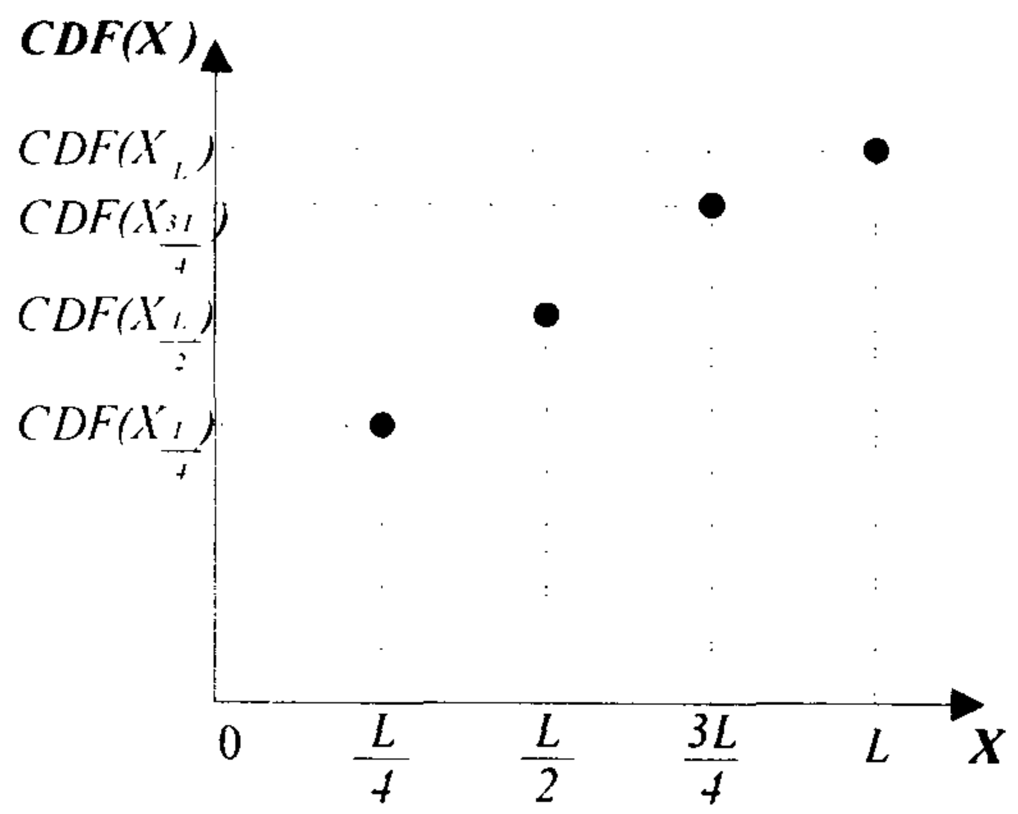

Figure 1. The CDF values at the sampling points

The output Y under the approximation method is represented as

$$Y_n = (\alpha X_k - \alpha x(n) - 1) \times NCDF_{sample}(X_k) + (\alpha x(n) - \alpha X_k) \times NCDF_{sample}(X_{k+1}) \quad (2)$$

where $n = 0,1,...,L-1$, $k \in \{0, \frac{L}{4}, \frac{L}{2}, \frac{3L}{4}\}$. X_k is the value at the sampling points kth. $x(n)$ represents the values at an nth input pixel. Then $NCDF_{sample}(\bullet)$ is the normalized CDF value at the sampling points. In this equation, we can observe that when L=255, the approximation result produce error at the low gray levels. Figure 2 illustrates two curves for accurate and approximated CDF. One drawback of the proposed method and previous histogram equalization can be found on the fact that the brightness of an image can be changed. To compensate an approximation error, we proposed decision algorithm and adjustment algorithm such as image enhancement factor, BLE, and WLE.

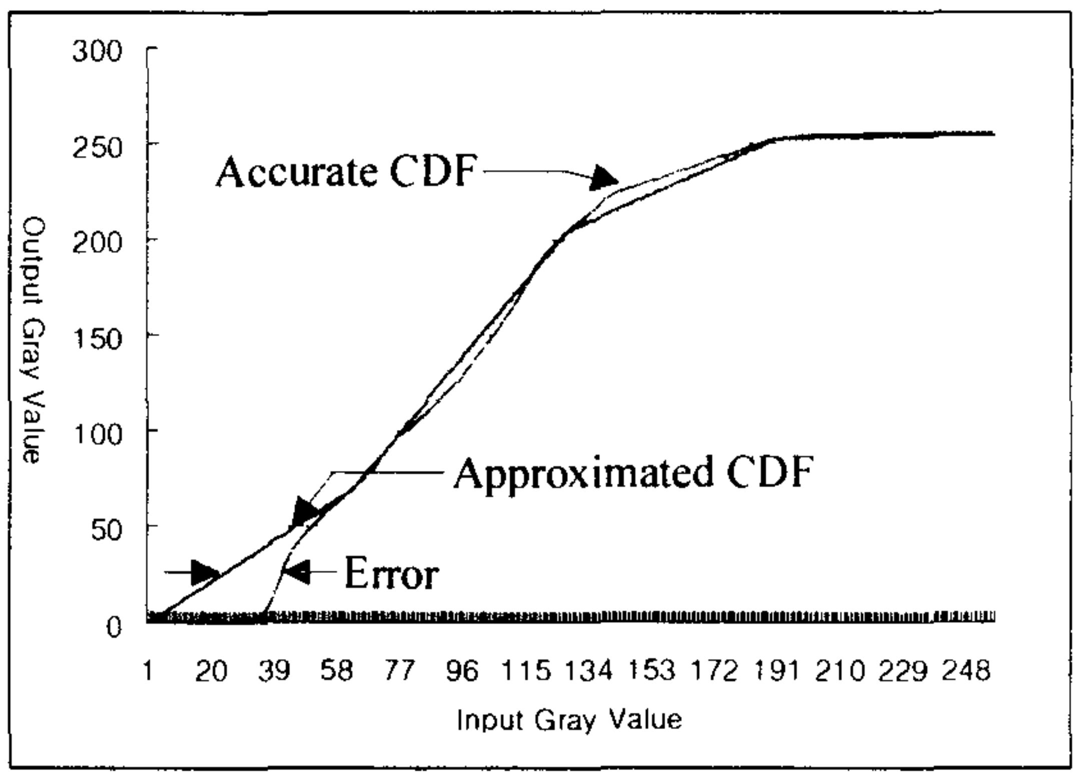

Figure 2. Accurate and approximated CDF curve for the sample image(lena image)

2.2 Black-level-expander and White-level-expander algorithm

Occasionally, we are desirable to improve contrast of range dark level or white level without changing the other one. For example, In the case of processed lena image, it is in need of BLE in order to improve contrast at low. Therefore, we have proposed enhancement algorithm such as BLE, WLE. It is possible that processed image can improve without affecting the other part. Figure 3 illustrate the characteristic curve of BLE and WLE.

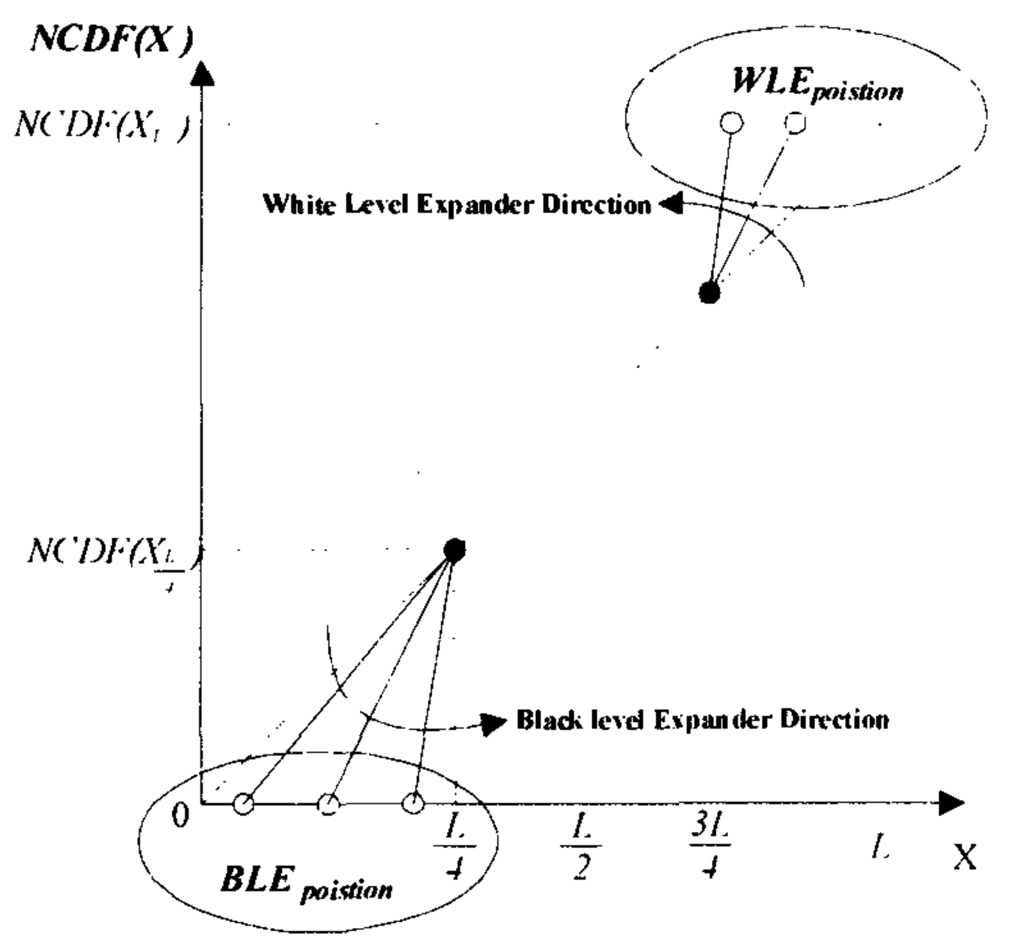

Figure 3. Characteristic curve of BLE and WLE.

The proposed method can be easily implements similarly by replacing the CDF value of sampling points, i.e., 0 is substituted for $BLE_{position}$ in dark image and L is replaced by $WLE_{position}$. The value of the $BLE_{position}$ or $WLE_{position}$ is characterized as

$$If(Dark\ image)\ then \quad (3)$$
$$BLE_{position} = \beta(X_{k+1} - X_k) + X_k$$
$$else$$

$$WLE_{position} = \beta(X_{k+1} - X_k) + X_k$$

end if

where $k = 0, \frac{L}{4}$ for dark image, $k = \frac{3}{4}L, L$ for bright image and $0 \le \beta \le 1$.

Equation (4) represents applied algorithm using equation (3).

$$\begin{aligned} &If(Dark\ image)\ then \qquad\qquad (4) \\ &\quad Y_n = (\alpha X_k - \alpha x(n) - 1) \times CE(X_k) \\ &\quad\quad +(\alpha x(n) - \alpha X_k) \times CE(X_{k+1}) \\ &\quad ,\ k = BLE_{poition}, \frac{L}{4}, \frac{L}{2}, \frac{3}{4}L, L \\ &else \\ &\quad Y_n = (\alpha X_k - \alpha x(n) - 1) \times CE(X_k) \\ &\quad\quad +(\alpha x(n) - \alpha X_k) \times CE(X_{k+1}) \\ &\quad ,\ k = 0, \frac{L}{4}, \frac{L}{2}, \frac{3}{4}L, WLE_{poition} \\ &end\ if \end{aligned}$$

where Y_n denotes output function and the same as previously proposed method such as equation (2). Thus, we have simplified implemented using change sampling point according to image characteristic.

Figure 4 shows the functional block diagram for the proposed image enhancement processor for H/W realization. The computation of the histogram needs to be done during one frame period. In order to store processed image, a frame memory is necessary as shown in figure 4. The procedure of the proposed image enhancement method is shown in figure 5.

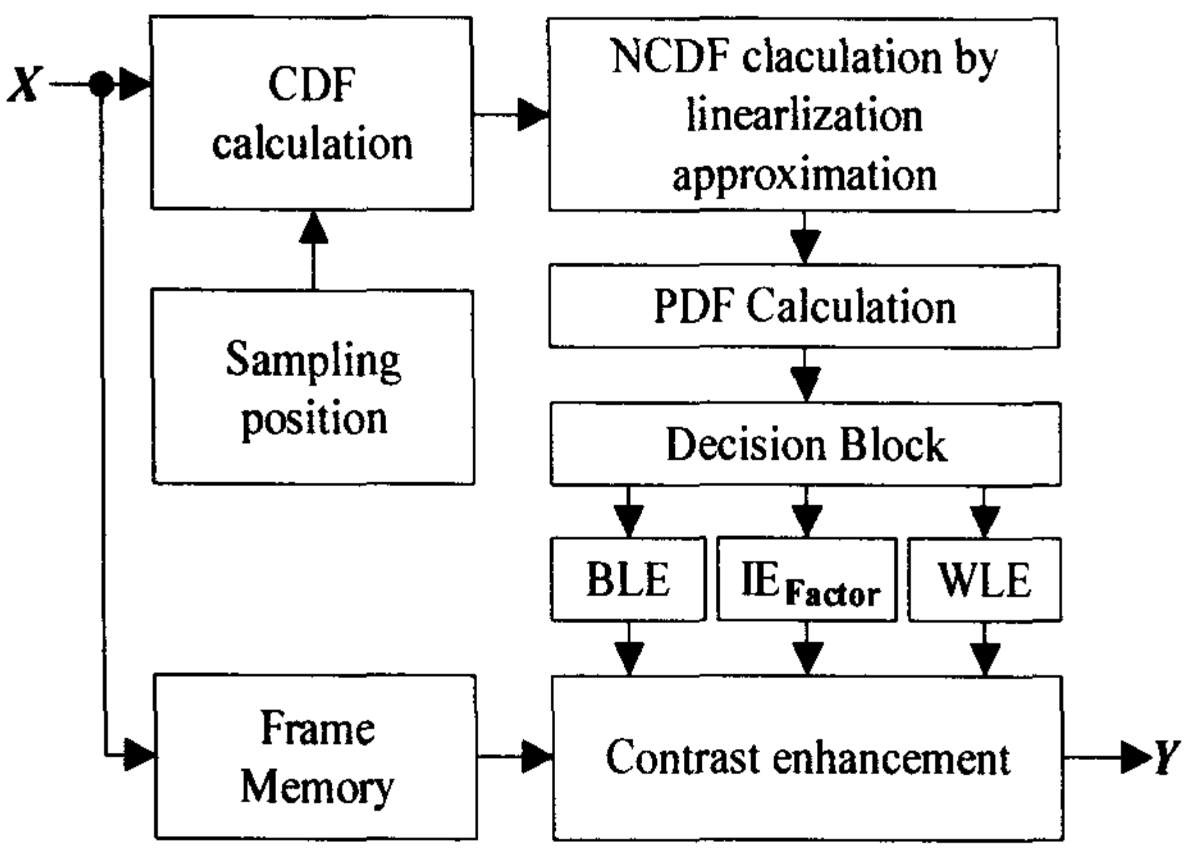

Figure 4. Block diagram of the proposed Method

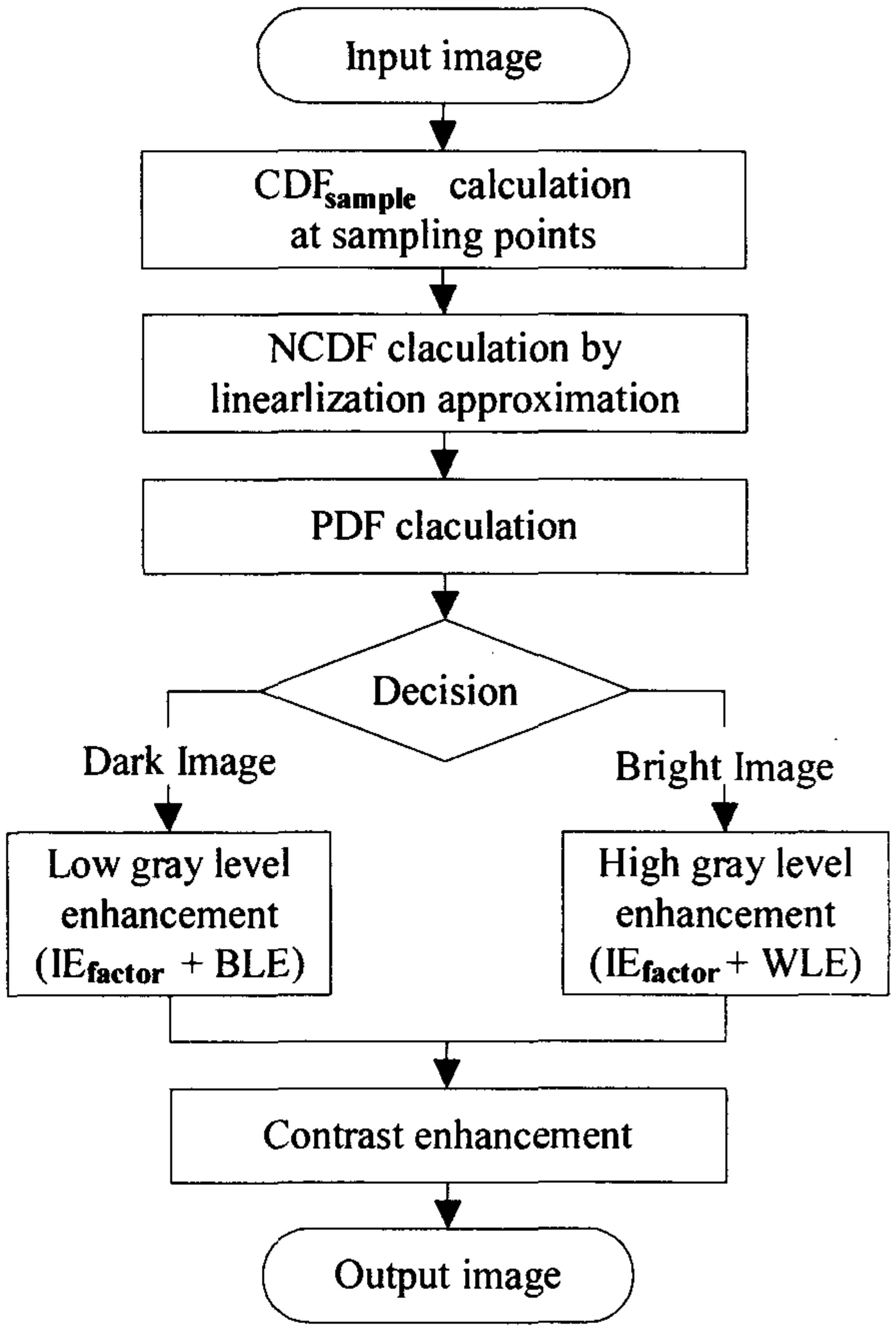

Figure 5. The processing procedure of proposed Method

3. Simulation Results

The described methods for improving the image quality are development and verified in computer simulation. The simulation results of the proposed methods for the given image are represented in figure 6. Figure 6 shows original lena image used for still image simulation and enhanced images obtained by improving factor such as IE_{factor}, BLE.

In the case of conventional method, the processed image produces defects as spots at partial region in image. Thus, the proposed method compensates for defects. Also figure 6-(c) shows that the processed image need to expansion at low gray level. The dark region enhanced image(fig. 6-(d)) is obtained by using BLE. In this image, we can observe that the contour of one's face and a hair became prominent in the bright region without affecting in the bright region on image. The output histogram of respectively processed images is defected in figure 7. The maximum contrast in the linear approximation and BLE scheme is achieved(fig.7 (d)).

Figure 6. Simulation results on lena image: (a) original, (b) conventional method, (c) proposed method using linear approximation, and (d) proposed image enhancement methods

In order to evaluate the performance of the proposed method in a still image, we measure standard deviation, mean, and median of the contrast enhanced image and original ones. Table 1 show the standard deviation, mean, and median change for the enhancing factor in the proposed method. The simulation results clearly show that the proposed method performs the typical histogram equalization in points. It is can controls a sudden change in image brightness using PDF and preserves the mean brightness of a processed image without affecting in the enhanced region.

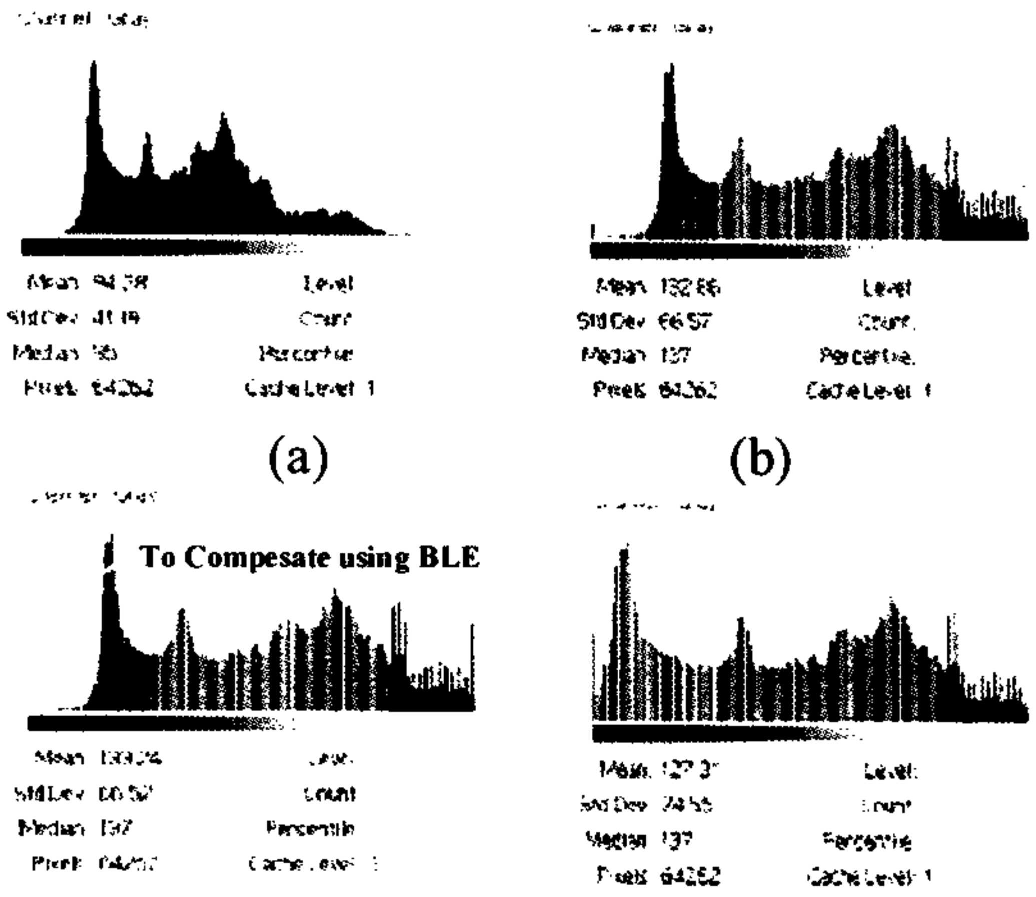

Figure 7. Histogram comparisons. (a) original, (b) conventional method, (c) proposed method using linear approximation, but it is in the need of compensation for low gray level gray, and (d) proposed image enhancement methods(addition to BLE).

Table 1. The comparison of the contrast enhanced image for various IE_{factor} values; Still image.

		Lena(Still image)		
		Mean	Standard Deviation	Median
Proposed IE_{factor}	10%	132.6	67.3	137
	20%	131.8	68.3	137
	30%	130.8	69.6	137
	20%	129.6	71.3	137
	50%	127.9	73.6	137
Conventional Method		133.2	66.5	137

4. Conclusion

In this paper, we have developed a newly image contrast enhancement scheme. The proposed method is a novel extension of a general histogram equalization, which utilizes information about approximated histogram and overall gray distribution of an image. The proposed algorithm has employed approximated PDF in order to control a sudden change in image brightness. The ultimate goal of our method obtains the maximum contrast of a given image without affecting in the enhanced region. In order to reduce hardware complexity, we have utilized approximated CDF based on sampling values. The major feature of our method can be improves image quality using information about image shape and BLE or WLE. Hence, many applications can be made by adopting the proposed scheme in the consumer electronics, such as PDP TV, LCD TV, and camcorder.

5. References

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