Contrast Enhancement of Images Using APLs in an AC-PDP

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Abstract

We describe the contrast enhancement of images using an APL(Average Picture Level) in an AC-PDP. A CEC(Contrast Enhancement Curve) determined by the APL was applied to enhance the contrast of images depending on the dominant gray levels. The most effective advantage of the proposed method is that it is easier to adjust the dynamic ranges to be enhanced with good quality and implement in a hardware system. The simulation result shows that the proposed method enhanced the contrast of given images significantly and kept the original brightness except the specific area of them compared to the HE(Histogram Equalization).

1. Objectives and Background

In the past few years, flat-panel devices such as PDP, DLP and LCD have been replacing CRTs quickly as a home television. Among them, the AC-PDP (AC-Plasma Display Panel) is one of the powerful candidates as wall-mounted flat-panel devices for a HDTV market because of a large screen size and higher image quality. In general, contrast ratio of images is one of the factors to acquire the better image quality in a flat-panel display. Also, many researchers have been done to enhance the contrast [1] for PDP as well.

This paper is organized as follows. The theory of the conventional contrast enhancement is introduced in section 2. In section 3, the details of the proposed contrast enhancement method that uses an average picture level of an input image are presented. In section 4, we applied the proposed method to the images and compared with the conventional histogram algorithms to show its effectiveness while section 5 concludes this paper.

2. Conventional Contrast Enhancement

The most popular approaches for contrast enhancement of images are Histogram modification based algorithms. Among them, the HE(Histogram Equalization) is one of the well-known algorithms for enhancing the contrast of given images according to the sample distribution of an image.

In general, the HE distributes pixel values uniformly and results in an enhanced image with a linear cumulative histogram. The HE is widely used due to its simple function and effectiveness.

However, drawbacks of the HE can be found on the fact that the brightness of an image can be changed mainly due to the flattening property of the HE, and that the range of gray levels to be enhanced is not specified, but whole [2].

In the subsequent sections, a novel contrast enhancement method, which is referred to the DCE(Dynamic Contrast Enhancement), is proposed to overcome the drawbacks of the typical histogram equalization mentioned above.

The ultimate goal of the proposed method is to enhance the contrast of given images while it keeps the brightness of these images. In addition, we could implement a hardware system simply.

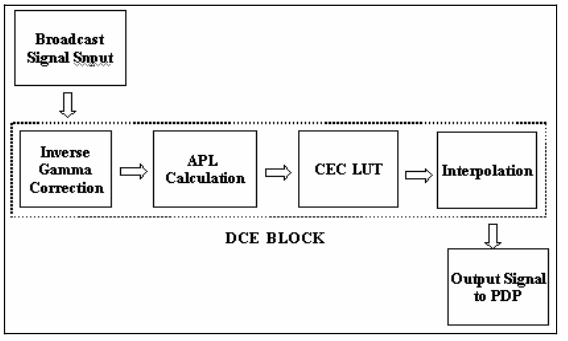


Figure 1. The proposed block diagram.

3. Novel Dynamic Contrast Enhancement

In this section, we propose the contrast enhancement method using CECs(Contrast Enhancement Curve) which are determined by APLs(Average Picture Level) as to achieve a wider dynamic range with its simple hardware implementation in PDPs.

Figure 1 shows the block diagram of the proposed method which is named as a DCE(Dynamic Contrast Enhancement). The first process of the DCE block was the inverse gamma correction. It was performed on input images so as to represent inverse-gamma corrected gray scales. This function has the equation:

$$O_i = 255 \times (\frac{I_i}{255})^{2.2} \qquad (1)$$

, where I_i is an input gray level and O_i is the output gray level of I_i. The value 2.2 is called the Gamma. The plot of the inverse gamma function is shown in Figure 2.

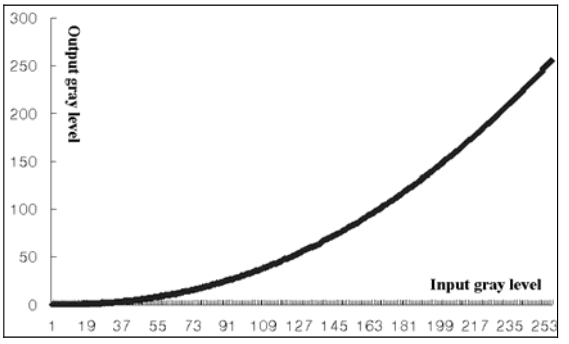
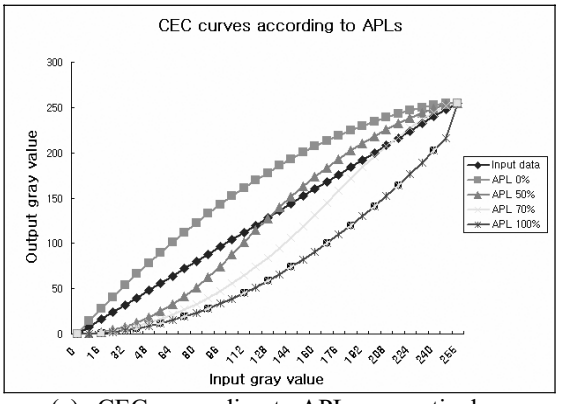
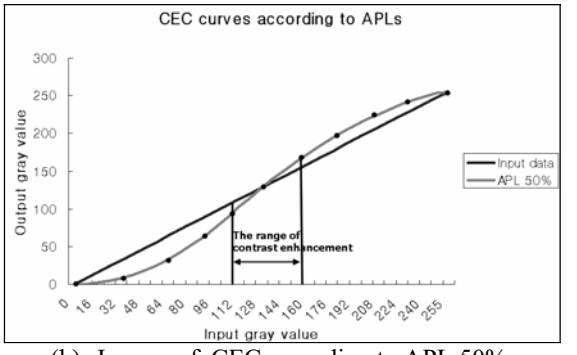


Figure 2. Inverse gamma function.



(a) CECs according to APLs respectively.



(b) In case of CEC according to APL 50%, N points of CEC are selected.

Figure 3. Contrast enhancement curve.

Some researchers have claimed that the APL is very useful for determining the amount of the power that a PDP TV will take and obtaining the maximum luminance and contrast ratio for higher image quality. It is a general measure of the average brightness within one frame. The APL is the average luminance of all pixels per frame, which is usually expressed as a percentage of the peak white luminance level [3]. The APL is calculated as the following equation (2).

$$APL = \frac{\sum_{i}^{T} G_i}{T} \qquad (2)$$

, where G_i is the gray value of an i^{th} pixel and T is the total pixel number in one frame.

We generate the contrast enhancement curves according to APLs respectively as shown in Figure 3(a). These curves are named

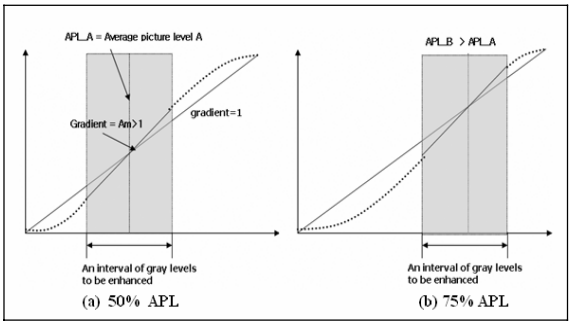


Figure 4. CEC according to APL : (a) 50% and (b) 75%.

as CEC. Figure 4 shows that the ranges of gray levels to be enhanced are moved according to the APL 50 % and 75 %.

However, the generated CEC needed a large amount of memory (ex. number of gray levels × number of APL levels) for a LUT(Look-Up Table). In order to reduce the memory size and regenerate the CEC, N-point values were selected and these selected point values were interpolated by using a PCHI (Piecewise Cubic Hermite Interpolation) which is one of fitting methods as shown in Figure 3(b). The method had no overshoots and less oscillation even if the data were not smooth. It, therefore, preserved the shape of a curve in itself.

The CEC LUT shown in Figure 1 is a look-up table which has N extracted point values on a CEC curve about M extracted APL values of whole APL values respectively. Therefore, the size of the CEC LUT can be reduced as many as N rows by M columns as shown in Table 1. For regenerating the contrast enhancement curves between APLs with the CEC LUT, the linear interpolation method was used. It is simple to design and implement in a hardware system and the interpolation results between APLs were similar to the original curve generated by the PCHIP fitting method.

The output images which were enhanced through the DCE block were directly transferred to other image processing blocks for display.

4. Simulation Results

In order to demonstrate the performance of the proposed method, the simulation results on an image *snow* are shown in Figure 5, 6 and 7.

Table 1. CEC LUT and the range of gray levels.

APL (%)	Range of Gray levels To be enhanced	CECs (N points per a curve)
0	0 ~ 16	CEC(0)
10	16 ~ 32	CEC (1)
25	32 ~ 64	CEC (2)
: : :	: : :	: : :
75	160 ~ 192	CEC (M-2)
90	192 ~ 224	CEC (M-1)
100	224 ~ 256	CEC (M)

In Figure 5, (a) shows the 2.2 inverse-gamma output image of an input image and (b) is the histogram graph of (a). The APL of the image is 55%.

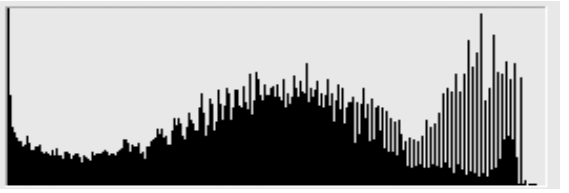
Figure 6 describes the output images acquired by the conventional algorithm HE. Figure 6(b) presents the image histogram which is stretched in the overall range. Because the mean brightness of the histogram-equalized image is always in the middle gray level regardless of the input mean. Therefore, the brightness of the output image as shown in Figure 6(a) is changed by the flattening property of the HE algorithm.

In Figure 7, (a) and (b) present the output images obtained by applying a CEC curve of APL 55% and its histogram graph respectively. In comparison with the Figure 5(a) image, the brightness of the output image shown in Figure 7(a) was not changed, but the contrast of the specific range of gray levels was enhanced. The histogram shown in Figure 7(b) proves that the shape of the original histogram was not much changed except the specified contrast enhancement range as shown in the box.

5. Conclusion

The proposed method using the CEC according to the APL can enhance the contrast of images in a PDP-TV. In the different way from the conventional method using histogram equalization, the specified ranges of gray levels to be enhanced can be adjusted according to APL values of images, and the brightness of an

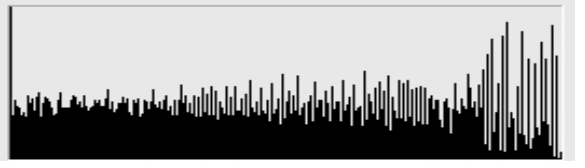
(a) Output image of inverse gamma



(b) The histogram of the image (a)

Figure 5. Inverse gamma Input image.

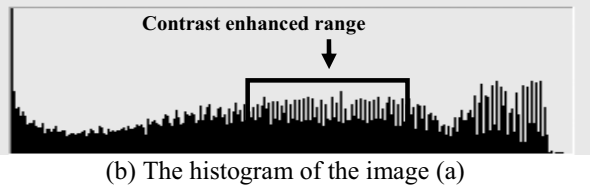
(a) Histogram equalized output image



(b) The histogram of the image (a)

Figure 6. The histogram equalization.

(a) The propose DCE output image



(b) The histogram of the image (a)

Figure 7. The proposed algorithm.

original image is not much changed. It is also easy to design and implement in a hardware system using the LUT and a simple linear interpolation method. The proposed method can enhance the contrast without brightness distortion.

6. Acknowledgements

The work was supported by PDP Circuit Group of Digital Display Research Lab. in Seoul of LGE.

7. References

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