Dynamic Gamma-Correction Algorithm for Improving Color LCD Systems

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***Abstract*-- This paper presents a dynamic gamma correction technology for improving color Liquid Crystal Display (LCD) systems. In order to reduce the hardware cost and improve the contrast and the edge strength, the proposed method efficiently improve the traditional designs which require complex calculation and high cost. Therefore, a modified dynamic gamma correction method is quite cost-effective. In addition, we implement the dynamic gamma correction algorithm in the FPGA platform.**

I. INTRODUCTION

The relationship between the LCD driving voltage and the transmittance is shown in Fig. 1. It is a nonlinear curve, due to the panel displays with the higher brightness image or the dark image, the image on the panel will become indistinct in outline. For that reason, the traditional method proposed a dynamic gamma correction method to adjust the gamma voltage which enhances the display quality [1]. But using dynamic adjusting gamma voltage method in the display system, it needs very high cost to implement the hardware.

Image processing technology based on Histogram Distribution (HD) method is important. In recent years, many researchers [2-4] have proposed some methods to broaden the dynamic range, they can enhance the image contrast. The methodology that uses Histogram Equalization (HE) and Brightness Preserving Bi-Histogram Equalization (BBHE) has been widely used in medical science and military image processing. But their computational complexity is quite large. The reference [5] provides a useful algorithm to improve image quality through the pixel-level contrast enhancement algorithm that uses the concept of Yin-Yout curve to improve the image contrast. However, this theory still has its drawbacks. It also needs 192 Look-Up Tables (LUTs) for Yin-Yout curves. Therefore, how to improve image quality and reduce the hardware cost are worth investigating.

II. ALGORITHM FOR THE MODIFIED DYNAMIC GAMMA CORRECTION

In the reference [5], the dynamic gamma correction is performed with Backlight Dimming Gray (BDG) level. The turning point of the Yin-Yout curve is modified by the BDG level. In order to reduce the amount of Yin-Yout curve, in this paper we present the usage of the Probability Density Function (PDF) as an image recognition method to determine the gray level distribution of image. The image is identified as high-brightness image, dark image, poor contrast image, or uniform image. A pixel-level contrast enhancement algorithm proposed in reference [5] was used to achieve gamma correction. We use automatic adjustment scheme to adjust Yin-Yout curve and to achieve dynamic gamma correction of the image processing. The modified dynamic gamma correction structure is described in Fig. 2. The first step, using the standard equation changes the pixel signals from RGB space into YCbCr space. This structure uses Canonical Signed Digit (CSD) fixed-coefficient multiplier to generate luminance feature Y.

Then, the Histogram Distribution (HD) features statistics is used to illustrate an image gray level distribution. The Histogram Distribution has 256 gray levels, divided into three regions. Let B be the region of the feature space form gray level 0 to gray level 127. Then Pb is the probability of dark image. Let M be the region of the feature space form gray level 85 to gray level 170. Then Pm is the probability of poor contrast image. Let W be the region of the feature space form gray level 128 to gray level 255. Then Pw is the probability of high-brightness image. In addition, if N is the total number of frame pixels, and the threshold value is 70% of N then Pth is the probability of threshold value. If $Pm > Pth$ then the Middle curve is selected. Otherwise, if $Pw > Pth$ then the Light-colored curve will be selected. Otherwise, if $Pb > Pth$ then the Dark curve will be selected. If not, then the Normal curve will be selected. The four kinds of Yin-Yout curve are shown in Fig. 3. Using the selected Yin-Yout curve and the feature Y of each pixel to generate enhance vector K for each pixel. Then input pixel data (R, G, B) is converted by K into display pixel data (R ', G', B'). Fig. 5, Fig. 6 and TABLE 1 show the simulated results of the proposed algorithm using MATLAB software. The amount of Yin-Yout curve is saved up to four curves. It is less then reference [5] proposed method.

III. IMPLEMENTATION RESULT OF THE PLATFORM

This paper provides a dynamic gamma correction algorithm that is based on image recognition technology and pixel-level contrast enhancement algorithm. In hardware design of FPGA-based driving system shown in Fig. 4, Xilinx's FPGA XC3S200 is used to implement the proposed dynamic gamma correction image engine. The image engine needs 15899 gate counts.

In the design of real-time processing, we use the current frame image feature vector to select Yin-Yout curve and employ the curve to achieve dynamic gamma correction on the next frame image. In other words, if the frame scan rate is 30Hz, then a new image will be corrected after 1/30 second. Fig. 7 shows the implementation results of the proposed algorithm. The left side of the screen is the original image. The right side of the screen is the transformed image.

IV. Conclusion

From the experimental results, we can conclude the high-brightness image and dark image after image processing can enhance image edge strength. The proposed algorithm makes the image texture details look more clear. However, it may sacrifice some contrast enhancement ability. For the poor contrast image, the image engine can enhance image edge strength and contrast. For the uniform image, the image engine can keep image properties.

References

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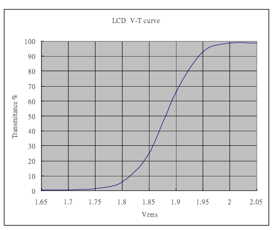

Fig. 1. LCD Voltage-Transmittance curve.

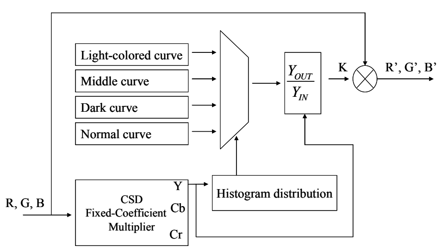

Fig. 2. Block diagram of dynamic gamma correction architecture.

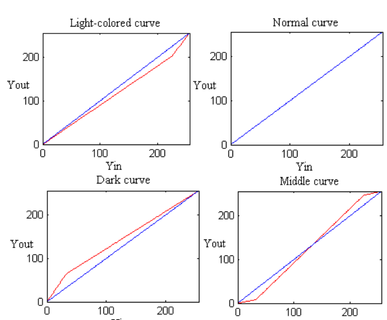

Fig. 3. The four kinds of Yin-Yout curve.

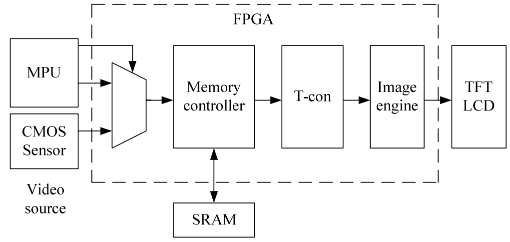

Fig. 4. Architecture of the FPGA platform.

Fig. 5. Original images.

Fig. 6. Simulation results of the proposed algorithm.

TABLE 1

	Figure 6.	Piano	Paris
Original	Max. brightness	256	148
	Min. brightness	1	1
	contrast	256	148
Results of the proposed algorithm	Max. brightness	256	163
	Min. brightness	1	1
	contrast	256	163
	enhance contrast	0.00%	10.13%
	enhance edge strength	yes	yes

Fig. 7. Implementation results of the proposed algorithm on FPGA platform.