Local Dimming Technique for High Dynamic Range LCD by White LED Backlight with New Control Algorithm

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Abstract

Dynamic range of LCD panel can be dramatically improved by adaptive dimming technique. Adaptive control of LED backlight by input signal can reduce the light leakage of LCD panel and achieve high contrast ratio. An algorithm is proposed to distinguish the input signal and get proper luminance level. For lower cost of LCD panel, white light LED is used to accomplish 2D dimming and get better image performance of LCD.

1. Introduction

The human eye can accommodate luminance in a single view over a range of about 10000:1 and is capable of distinguish about 10000 colors at a given brightness. In recent years, The FPDs are widely used in TV and monitor market. TFT-LCD panel have made fast and dramatic advancement with performance and surpassing other type of FPDs. In conventional LCD panel, uniform and continuous lighting backlight is used for TFT-LC cell. The brightness is controlled by changing the transparency of each TFT-LC pixel. Light leakage is the most serious drawback of LCDs when we concern about the contrast ratio of LCD panel. Recently, adaptive dimming technology had broadly used [1-3] for many kinds of backlight source, ex, CCFL, HCFL, EEFL and LED, etc. Dimming techniques of backlight not only improve the performance of contrast ratio but also reduce the power consumption of LCD. The dimming type is used differently for different kind backlight source. The LED backlight is a better way to reach local dimming technology due to its advantage of individual control. For RGB LED backlight, it can accomplish the 2Dcolor dimming. Cooperating with well algorithm, RGB LED backlight will exhibit an excellent performance of image quality. But nowadays, the cost of LCD panel with RGB LED backlight, compare with CCFL light source, will be too high for general consumers.

In this paper, we propose a proper way to achieve 2D dimming and get better dynamic range for human eyes. 8x8 segments of LED backlight unit are constructed for 28 inch multipurpose TV/monitor LC displays. White light LED and color filter are selected properly to get better color reproduction.

2. Backlight Dimming

Liquid crystal display can not emit light by itself. The brightness is supplied by backlight and the gray level is controlled by liquid crystal as a light valve. But LC can not stop the light perfectly and cause leakage of light. Backlight intensity product LC panel transparency provides the observers pixel brightness percipience. The more luminance of backlight is provided, the more serious of light leakage is caused. In other words, light leakage can be reduced by dimming the backlight when the image is dark.

The backlight dimming technique reduces not only the light leakage but also the power consumption. Several backlight dimming methods have been reported [1-3]. The purpose of these papers is focus on reducing power consumption. But the methods of them are also useful for deceasing light leakage. Global dimming of backlight due to input signal can improve the dynamic contrast, but the static contrast can not improve properly owing to the bright and dark sight are all reduce the brightness of backlight. Local dimming technique can achieve a better performance that global dimming can not do. Some paper combines local and global dimming to get better image performance [4].

LED provides a good source for dimming technique due to its good characteristics, such as fast response time, easily to be controlled, and color reproduction, etc. Compare with other type of light source, LED backlight can accomplish 2D and 2Dcolor dimming technique to perform better image quality. Figure 1 shows the concept of local dimming performance of input signal. The contrast ration is improved by backlight dimming evidently.

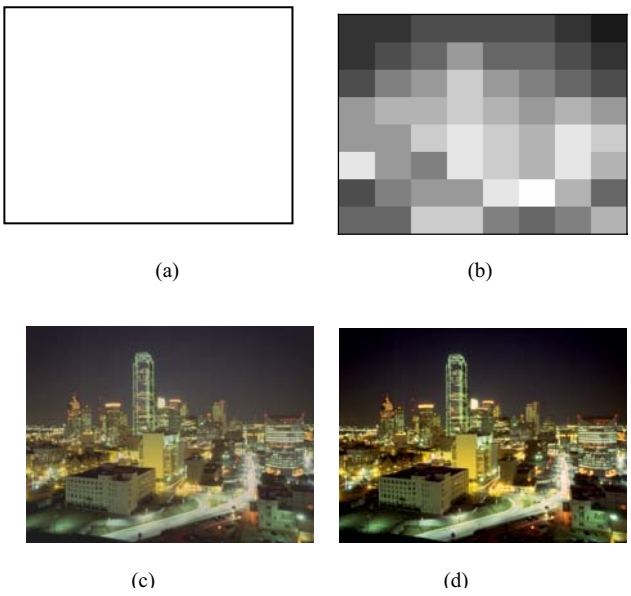


Fig. 1. The concept of local dimming technique.

3. Results and discussion

3.1 Algorithm

Generally, the backlight luminance level of 2D dimming is selected by input image Luma (Y) histogram analysis. Unfortunately, histogram analysis of Y information can not provide proper information at some situation, such as totally R, G, or B color. Because the Y information is composed by different weighting RGB color. For example, NTSC RGB signal transfer into NTSC YIQ, equation (1):

$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ 0.596 & -0.275 & -0.321 \\ 0.212 & -0.523 & 0.311 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad (1)$$

The grate part of input image data is blue; the Y data will be low. If Y histogram data is selected to analyze, we will not get a suitable gray level of backlight. Therefore, analysis of Y histogram is not enough, the RGB histogram should be considered to select proper backlight dimming level. In our algorithm, R, G, B and Y histogram of image are all concerned to get better image performance. Figure 2 shows the state flow of backlight dimming. LCD panel signal is compensated according to input signal.

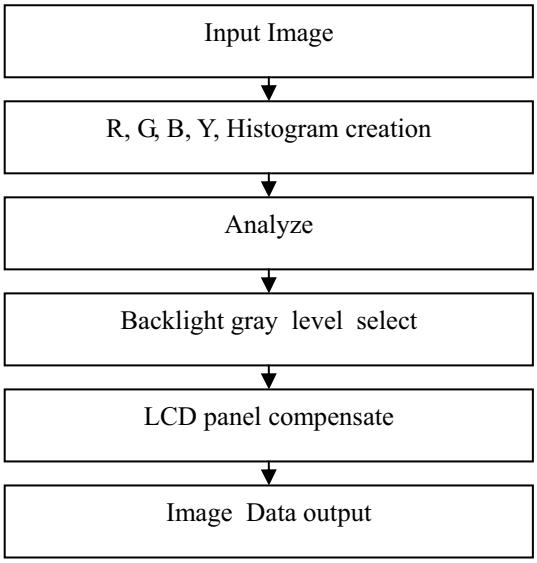


Fig. 2. The state flow of backlight dimming control.

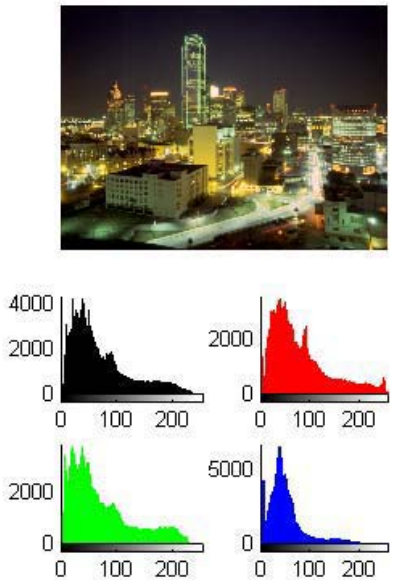
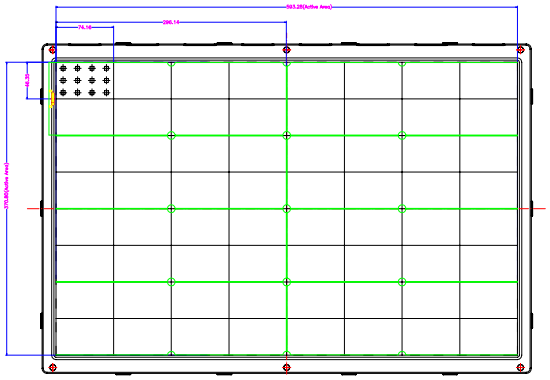


Figure 3. R,G,B,Y histogram analysis of input image.

3.2 LED Backlight Unit

In this paper, we use white light LED and separate 8x8 segments for individual luminance control. Each control unit contain 12 piece LED and be controlled by PWM (Pulse Width Modulation) module. Total panel contain 768 piece LED. 28 inch backlight unit is demonstrated.
Figure 4 show the plot of backlight.



(a)

(b)

Fig. 4. 28inch Backlight unit. (a) Structure. (b)Control unit.

Compare to RGB LED, the color reproduction of white light LED is poor. But the cost of three chips RGB LED is too high, we use blue LED plus R and G phosphors three wavelength LED to get better color gamut than normal two wavelength LED. In figure 5, white light LED with three-wavelength is showed. We use Gaussian distribution to fit the measured spectrum. In order to get better color gamut, we select proper white light LED and color filter spectrum.

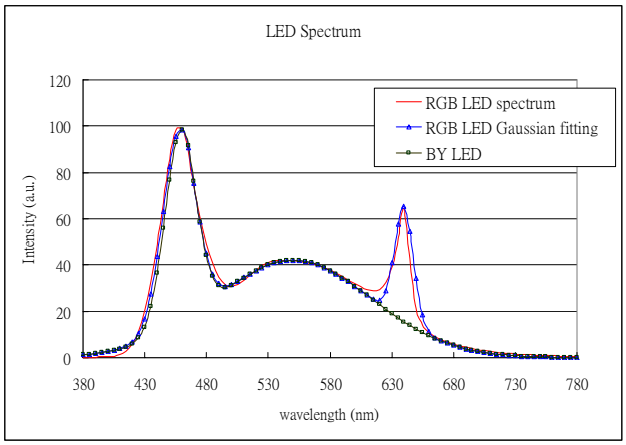


Figure 5. White light LED spectrum.

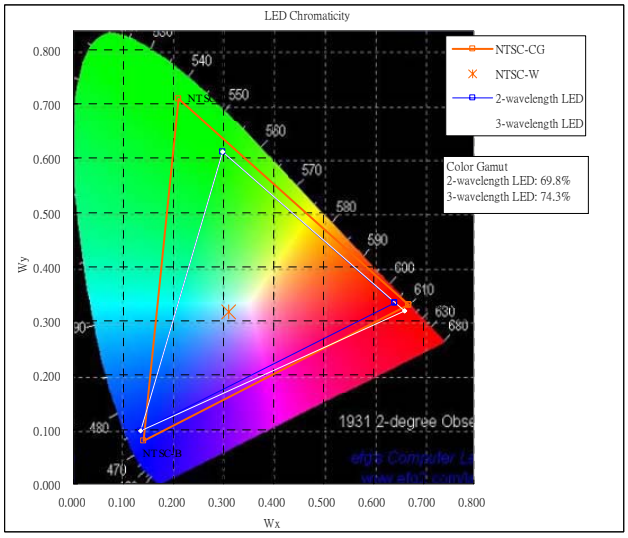


Fig 6. White light LED chromaticity.

4. Summary

In this paper, we apply local dimming technique to 28 inc h TV/Monitor multipurpose LCD to achieve high dynamic r ange. Compare to RGB LED, white light LED is used to re duce cost of backlight module. White light LED with three-wavelength is selected to perform higher color gamut than t wo-wavelength white light LED.

5. References

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