Development of Narrow Viewing Angle Mode TFT LCD and Application of Advanced Gray Compensation (GC) Algorithm

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Abstract

In the viewing-angle image control (VIC) technology, one pixel is made up of a quad pixel structure which is consisting of R, G, B, and electrically control birefringence (ECB) sub-pixels. Two types of test stimuli were used; text & complex image respectively. The limitations of those methods were found from the experiment. From the results the advanced GC technology was proposed.

1. Introduction

VIC stands for a controllable narrow viewing-angle display mode for users who want to keep their privacy[1, 2]. Recently, mobile display is widely used, and many people who use a personal display device worry about being revealed their personal information. In order to fulfill these requirement, a protect film[3] which can restrict a direction of light was introduced for LCD. In the case of applying a film to the LCD, the total cost of the display device can be increased than conventional type of display. Furthermore, the luminance of the display used the film can be significantly decreased. So, a new technology is required to solve these problems without protect film.

This study is about the matter of VIC function which embodied on single panel of TFT LCD. In the previous study, VIC function of TFT LCD had developed, however, the structure of quad pixel caused a limitation of narrow viewing-angle mode at an especial border of text and image patterns[2]. Therefore, current study was focused on the improvement of this limitation.

2. Experimental

In case of GC, owing to the conception of pixel structure and viewing angle characteristic [Fig 1], high-light appearance comes into luminously existence at a border of text. In here, Luminance summation of adjacent quad pixel shows that human eye vision does not discern only one quad pixel physically also neighboring quad pixel [Fig 2].

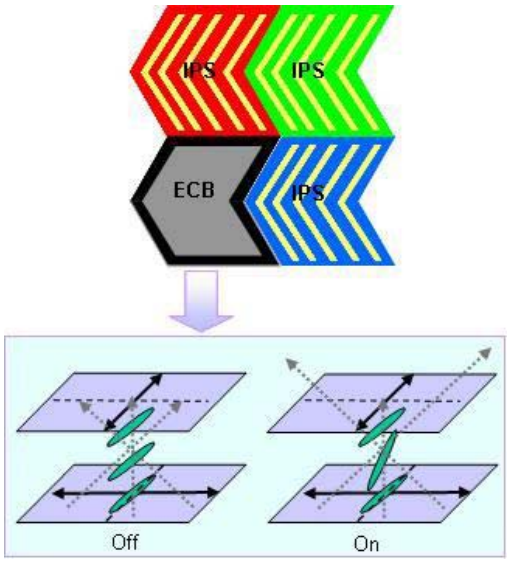

Fig. 1. Pixel structure and viewing angle characteristic.

Same as upper phenomenon, the high-light becomes visible at the interface of the arbitrary text stimulus.

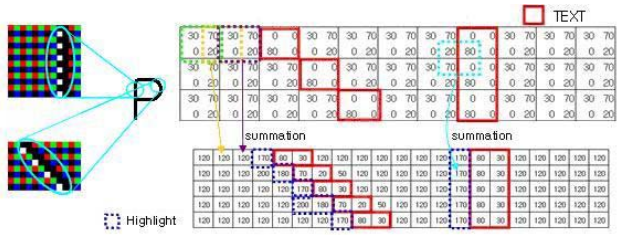

Fig. 2. Luminance Summation of a neighboring quad pixel at the 45 ˚ of viewing direction.

We tested with the following text stimulus at the 45 ˚ of viewing direction [Fig 3]. and then found a specific gray level of background that high-light phenomenon disclosed on the text stimulus according to changing the value of gray level at the same time.

Consequently pixel's luminance of text itself and

background is transferred. We can calculate the luminance summation of single quad pixel at horizontal one step by step.

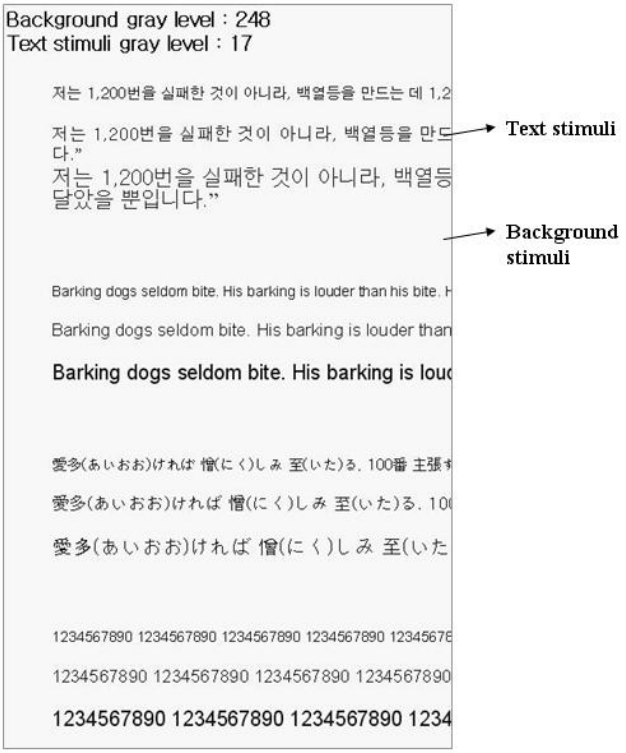

Fig. 3. Test stimuli at each gray level. (Total 92 pages)

3. Results and discussion

At the 45 ° of viewing direction, VIC LCD panel which used in GC algorithm have equivalent luminance level at all grayscale, because the ECB sub-pixel is controlled independently and compensates for the target luminance as shown in Figure 4. In the case of GC at a text stimulus, this technology can be easily detected and recognized by human visual system at 45 ° .

Figure 5 shows the luminance summation of each adjacent square pixel at between 192 gray of background and 150 gray of text. In this figure, the vertex of each line can be seen high-light, which means looks brighter than surrounding pixels.

Generally, this phenomenon can be occurred at the border of the text and image stimulus owing to the structure of quad pixel.

Figure 6 is the relation between the grayscale of background and the vertex of luminance summation, which means that ECB sub-pixel's luminance has to be controlled underneath this curve.

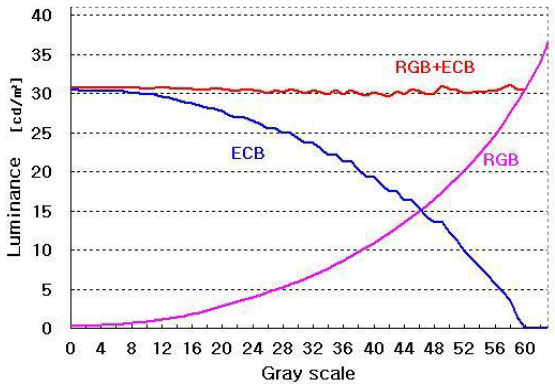

Fig. 4. Luminance at 45 ° viewing-angle using GC.

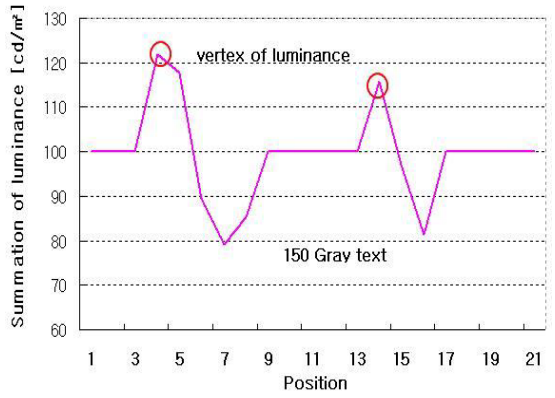

Fig. 5. Horizontal summation of luminance at 150 gray text.

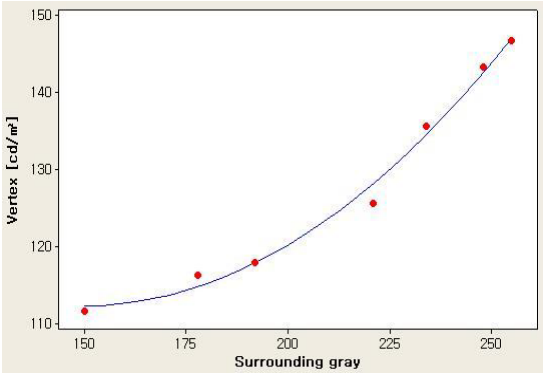

Fig. 6. The regression curve of visible high-light luminance.

Figure 7 describes the advanced GC algorithm. In this algorithm, the ECB sub-pixel's luminance swings regularly and the center value of the swing depth does not fall down. This technology makes a multiplicity of borders at a displayed image to the human visual system. This multiplicity interfere the cognition of displayed information.

The width of luminance variation in Figure 7

should be determined properly, while the new GC algorithm is applied to LCD at the front of screen. Otherwise, the multiplicity of borders at a displayed image can be detected in the edge of the display as a noise.

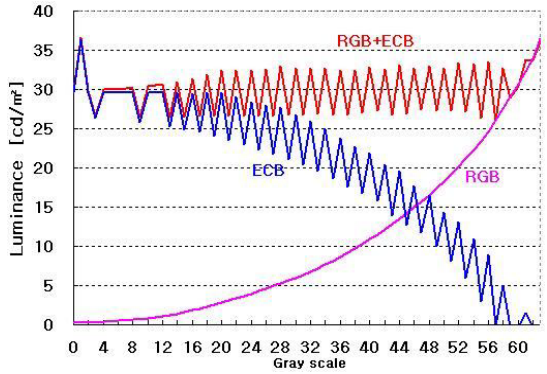

Fig. 7. Grayscale luminance using a new GC algorithm.

Therefore, a prototype model (14.1" 1280x800) was developed and operated to adjust 0.8~1.2 Contrast Ratio (CR) among the neighbor grayscales.

4. Summary

The motivation of this study was to solve the high-light phenomenon due to the quad pixel structure in GC type of viewing angle image control technology. GC algorithm is a kind of opposite idea which gray inversion basically causes the distortion of display image. For this image's deformation, ECB sub-pixel which is one of the quad pixels can be operated upper and lower target luminance. In this algorithm, VIC effect can be made narrow more 10° in horizontal direction.

5. References

1. Y. Hisatake, et al., "Viewing Angle Controllable LCD Using Variable Optical Compensator and Variable Diffuser", *SID05 Digest*, p.1218~1221
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3. http://www.eyean.co.kr/