Novel Measurement method for Image Sticking based on Human Vision System

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Abstract

This paper introduced a measurement method for image sticking based on human vision perception. Existing image sticking quantification method is mostly different from visible level by human perception. It takes a long time to measure image sticking which is degraded by time due to using a spot photometer, therefore many test samples could not be evaluated in a given short period of time in mass production line. However, the new measurement method in this paper is possible to evaluate a large quantity of samples in fast and high correlation with human perceptual level of image sticking.

1. Introduction

In recent years, the picture quality of FPD (Flat Panel Display) is getting more and more important. So it requires more evaluation items and methods for visual quality of display devices. But some visual quality is very difficult to measure and quantify, for example image sticking, Mura, motion artifacts, and so forth. Image sticking phenomenon occurs after certain image information has been displayed for a long period of time, the residual image still exists even if the previous displayed image information has been refreshed and changed to a new image. Because the difference of luminance before and after image sticking is very small, the small amount of errors from measurement could have much influence upon image sticking quantification. An analysis algorithm which can distinguish small luminance change is very difficult. Therefore, inconsistency always exists between results of visual inspection and quantified evaluation method. This may give rise to make strong argument between suppliers and customers. The results of visual inspection could be varied with human visual inspectors. This could be a huge loss for both parties so that the novel objective measurement method with high correlation with human visual perception should be necessary to develop.

2. Background

1) Optical Illusion

The subject of this paper is quantification about LCD's image sticking phenomenon. Fig.1 shows image sticking phenomenon and its luminance values in LCD display using a chessboard pattern.

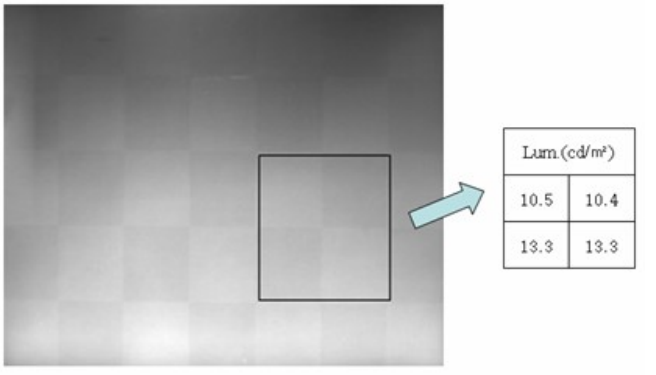

Fig. 1 Image sticking in LCD and average luminance of each 4-area

When average luminance of each 4-box area by 2D-CCD type luminance meter was measured, there is a difference between measurement luminance and its perceptual brightness. It means that perceptual amount

of image sticking could not be quantified with simple luminance measurement. In that reason, an optical illusion which brought up those sensational mismatches should be investigated. There are many kinds of optical illusions. The Craik-O'Brien-Cornsweet illusion discovered by Tom Cornsweet in late 1960s connects with image sticking in optical illusion phenomenon. This was known as Craik-Cornsweet illusion or the Cornsweet illusion.

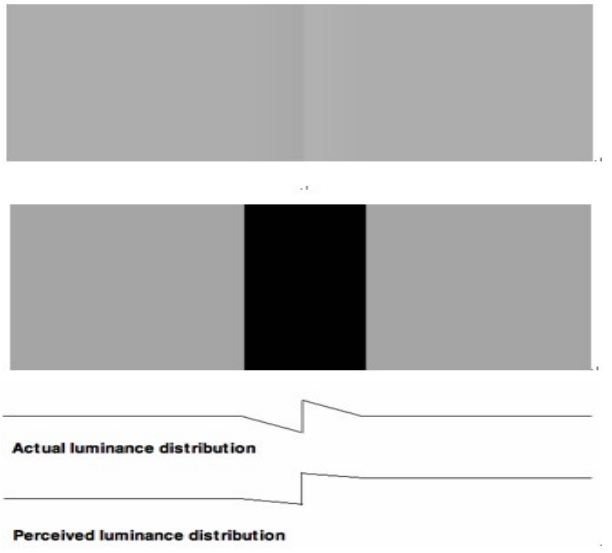

Fig. 2 Cornsweet illusion phenomenon

Fig. 2 explains well about the Cornsweet illusion phenomenon. In the image above, the entire region to the right of the "edge" in the middle looks slightly lighter than the area to the left of the edge, but in fact the brightness of both areas is exactly the same, as can be seen by blacking out the region containing the edge. This optical illusion explains that changing in very small area of the interface between two different contrast influences on entire area to have different perceptual feeling. In this paper, we consider this illusion phenomenon applying to quantification algorithm for image sticking analysis method.

2) Problems of existing image sticking measurement

The quantification of image sticking has a great role to improve LCD's image quality. Variety of International Standards or organizations have defined image sticking quantification methods. Also companies of industrial circles have devised corrected quantification methods considering each own environmental conditions. But in the case of weak level of image sticking shown in Fig.3, it is almost impossible to be distinguished from another phenomenon such as light-leakage, Mura, and so forth. So it was very difficult to do objective and correct assessment using quantification value measured by optical measurement devices which applying human visual perception characteristics.

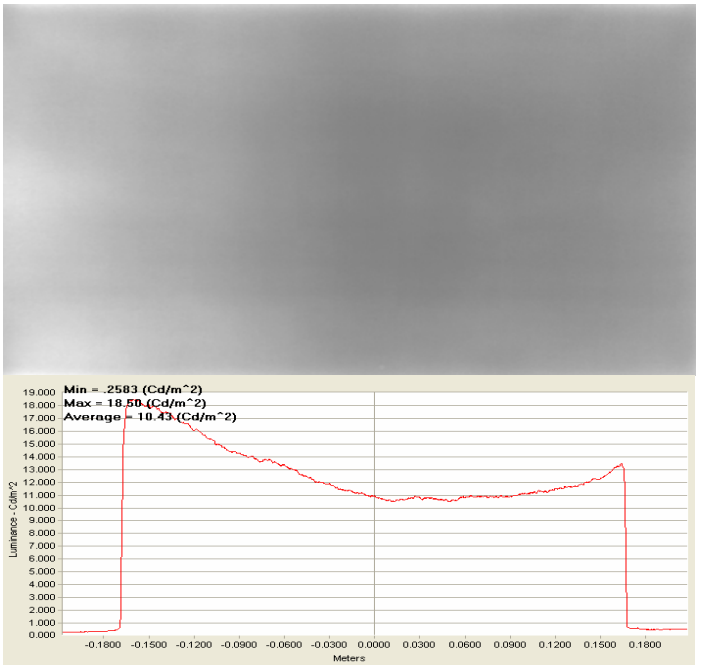

Fig.3 Horizontal luminance cross-section distribution on image sticking pattern for weak level of image sticking

There are several image sticking measurement methods. Among those, a representative method is introduced by the VESA FPDM 2.0 (Video Electronics Standards Association - Flat Panel Display Measurements 2.0). Fig.4 shows brief explanation about the measurement method of image sticking. Because the difference of luminance is very small between initial and final measurement by image sticking, it must be necessary to measure on the exact same three locations throughout the procedure. Because of this, initial setup environment has to be kept continuously. Usually, because applying certain type of image sticking generation pattern must have been done for 5~10 hours before release the pattern, this type of image sticking measurement method is not proper to measure for many samples in a short period of time.

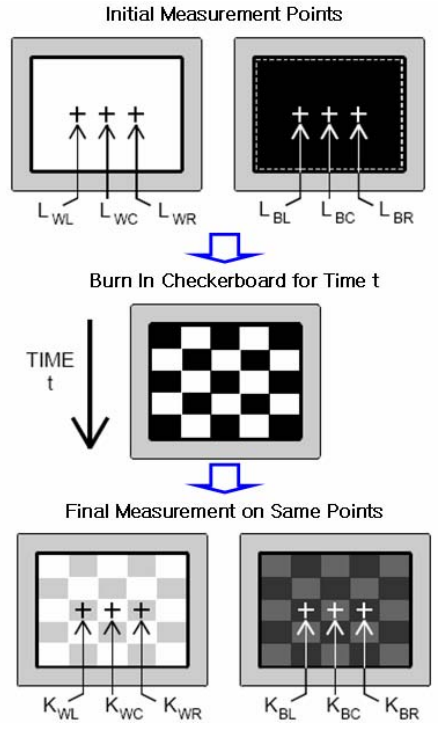

Fig.4 Image sticking measurement method in VESA FPDM2.0

3. Experimental Procedure

The advantage of a new image sticking quantification proposed in this paper is to agree with human perception very well and there is no need to do initial measurement. To correspond with human perception, we need to take a measurement at whole area of a LCD panel. The 2-Dimension CCD photometer (Prometric 1423, Radiant Imaging Company) was used in this experiment. First, a DUT (Display under Test) were applied an image sticking 7X5 chessboard pattern without initial measurement. After exposing this pattern for a certain period of time, the measurement was done in the state of the same pattern and then produced border position of all each box as Fig.5. The image sticking pattern was applied to DUTs for 10 hours in this experiment.

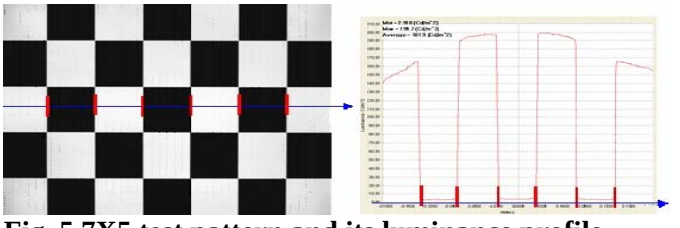

Fig. 5 7X5 test pattern and its luminance profile

As mentioned in previous section, when a visual inspector recognizes image sticking, the border of high and low gray pattern is more important than its area. Because of the cornsweet optical illusion phenomenon, we measured luminance of the border area instead of average luminance of whole area of chessboard box and applied analysis algorithm for image sticking measurement. And then whole area of DUT on full gray of half luminance was measured and extracted luminance data of each border area as shown in Fig. 6.

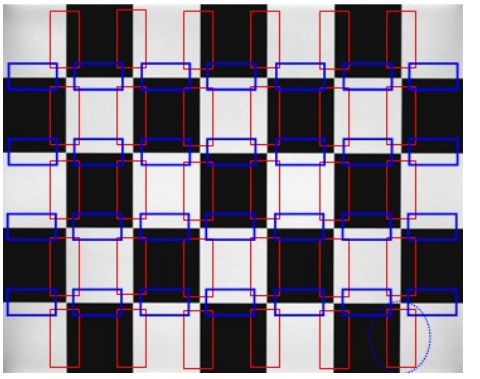

Fig.6 The border area for image sticking analysis

After that, BCV(Border Characteristic Value) was calculated using the luminance data profile extracted in Fig.7 and Equation(1).

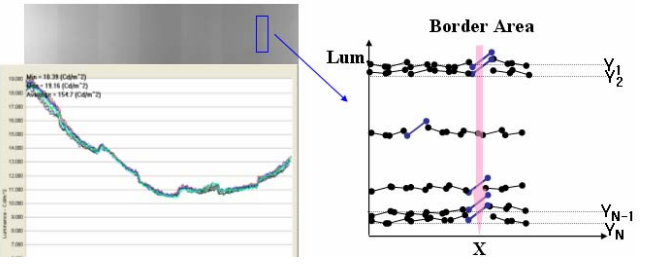

Fig.7 Calculation of BCV(Border Characteristic Value)

$$BCV\ (\%) = (Z / N) \times 100 \quad \cdots\cdots\cdots Equation\ (1)$$

In Eq.(1) "Z" is the number of repetition times at X coordinate that has max difference of luminance and "N" is total number of data in Y axis.
The maximum value among calculated BCV could be represented its amount of image sticking.

4. Results and Discussion

The 40 number of LCD panels were evaluated using visual inspection and novel objective measurement method to assess the level of image sticking. Normally, the level of image sticking could be ranked in 5 steps shown in Table 1. Experimentally, the level of 3 could be a fail classification in quality assurance process.

Table 1. Visual inspection level vs. image sticking phenomenon

Visual inspection level	Image sticking phenomenon
Level 1	No image sticking
Level 2	Difficult or vague to identify types of image sticking.
Level 3	Easy to identify types of image sticking.
Level 4	Clear image sticking
Level 5	Very much clear image sticking

And then we measured the same LCD samples in accordance with new quantified measurement which was proposed in this paper. The *BCV* of new quantified measurement is expressed from 1 to 100.

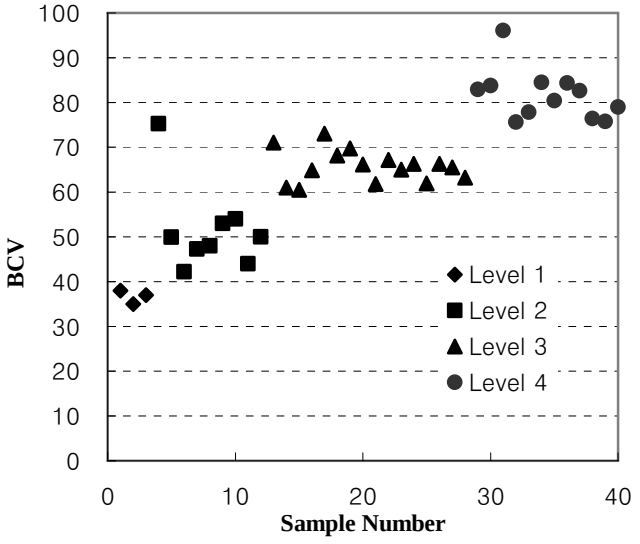

Fig. 8 BCV values with corresponding to visual inspection levels

The comparison result was showed in Fig.8. The visual inspection level coincides with *BCV* over 95%. In fact, human eye is generally sensitive more than any optical equipment. But the visual inspection is very subjective so that large possible variation exists between inspectors. This could be a huge loss for both developers and users. The novel objective measurement method with high correlation with human visual perception could be a promising solution not only for enhancement the visual quality of the display but also for reduction of hidden process loss during manufacturing. Being different from existing methods, the presented image sticking measurement method showed results being very much similar to human visual perception with fast measurement speed. Therefore, this new metrology is very useful of picture quality evaluation at mass production.

5. References

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