P-33: A Measurement and Analysis Method of Image Sticking in LCD

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Abstract
In this paper, the evaluation method of image sticking was proposed by measuring 2-Dimension of luminance level. We used the 2D-CCD luminance meter and pattern generator for chessboard pattern. The test samples were burned in about 2 hours and the tested data were normalized by data before image sticking test. The normalized value was so sensitive for determining the image sticking level. We proposed a new parameter of ISV(image sticking value) for increasing sensitivity. It was resulted that the image sticking under ISV 1% was difficult to be detected by human eye. And the image sticking over ISV 2% was strongly detected. It was found that this test method is similar to human eye testing result. Therefore, this analysis method helps to determine the objective image sticking level.

1. Introduction
The recent growth of LCD market has been further accelerating the demand for TV & monitor display systems. And it needs more supply capability and lower cost. Also it needs higher level of image quality. And most of performance of LCD measured by photometric & colorimetric method. But some visual image quality is very difficult to measure by traditional method. Especially, image sticking, one of important quality, is getting critical issue to Liquid Crystal Display. After a static image has been displayed on a LCD for a long time, the image remains while displaying the next pattern. This phenomenon is so-called image sticking effect, and has been considered to result from electric voltage difference by ionic charge effects. And we can separate two phenomena. One is line image sticking and the other is face image sticking. The general method of evaluating the image-sticking phenomenon is human eye detecting. But the result is depending on subjective decision of each people or each company. Some people have been widely studied by using voltage, current, capacitance, and optical performance for image-sticking analysis. However the electrical measurements give fluctuating result when impurity ions transport. And optical measurement result is lower sensitive than human eye. Also, some testing method was calculated the image sticking by using non-uniformity concept of specific measuring point. But the occurring location of image sticking is random. And it is very difficult to find an optical testing method for determining an image-sticking factor perfectly. Generally, Optical-measuring data is only a physically measured data. And image sticking is an ergonomic problem for human eye. It is important that the optical measured data is analyzed ergonomically.
In this study, we propose a new objective and ergonomic analysis method about image sticking phenomenon by normalized 2-D mapping with each position.

2. Method & Process
2.1 Measurement Instrument
We need to take a measurement at many point because image sticking is depend on DUT(Display under Test) position. In case of sopt detectors it takes a long time for the measurement with positioning system. Therefore we used the 2-Dimension CCD luminance meter in this experiment. The name of equipment is the Muratest of ELDIM Company. Figure 2 shows the equipment concept. Our test panel use pattern generator (VG-852) and power supply for driving. This experiment was tested in dark room state. And reference test pattern is full gray of half luminance & low-level luminance and burn-in pattern is 8 x 6 chessboard pattern.

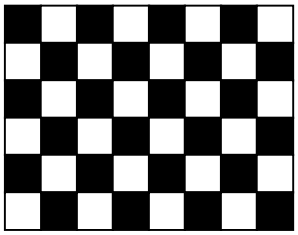

Figure 1. The test pattern for image sticking

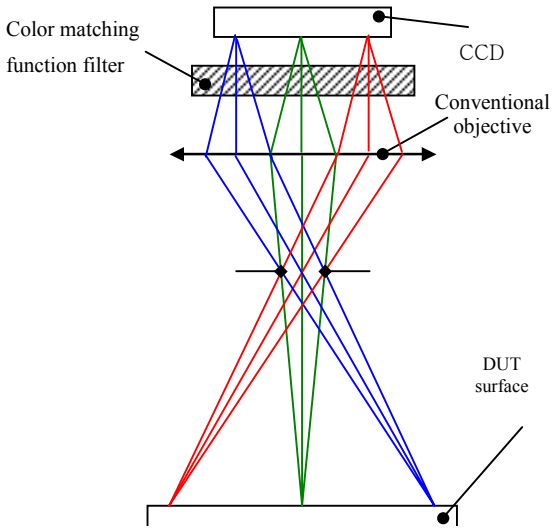

Figure 2. Basic concept of measurement system.

We used an optical bench for alignment between DUT and 2-dimension CCD luminance meter. We used the limit samples determined by human eye for image sticking phenomena.

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2.2 Measurement and Analysis method

At first, it was measured the luminance of full half gray level to acquire the reference data group by using CCD equipment. And then, DUTs were burned in 8 X 6 chessboard pattern about 2 hour the test sample. We measured the position of chessboard pattern to determine the seven-analysis area. After changed to full half gray, the luminance was measured to determine the image sticking.

Formula 1 shows that normalizing method of the before & after data group, and mapped the normalizing data group. If the test sample have not image sticking state and luminance stability characteristics will be stable perfectly, the normalized data value of each point will have "1" or the data value of each point will change lower & over one. In this formula, "IS" means the luminance data after image sticking test. And "L" means the luminance data before image sticking test. And then, we re-draw the normalized data group. And we retrieved the horizontal data. The numbers of the tested data in horizontal line are 250s

$$\begin{pmatrix} IS_{11} & IS_{12} & \cdots & IS_{1n} \\ IS_{21} & & & IS_{2n} \\ IS_{31} & & & IS_{3n} \\ \cdot & & & \cdot \\ IS_{m1} & \cdots & \cdots & IS_{mn} \end{pmatrix} \Big/ \begin{pmatrix} L_{11} & L_{12} & \cdots & L_{1n} \\ L_{21} & & & L_{2n} \\ L_{31} & & & L_{3n} \\ \cdot & & & \cdot \\ L_{m1} & \cdots & \cdots & L_{mn} \end{pmatrix} =$$

$$\begin{pmatrix} \left(\frac{IS_{11}}{L_{11}}\right) & \left(\frac{IS_{12}}{L_{12}}\right) & \cdots & \left(\frac{IS_{1n}}{L_{1n}}\right) \\ \left(\frac{IS_{21}}{L_{21}}\right) & \cdots & \cdots & \left(\frac{IS_{2n}}{L_{2n}}\right) \\ \cdot & \cdots & \cdots & \cdot \\ \cdot & \cdots & \cdots & \cdot \\ \left(\frac{IS_{m1}}{L_{m1}}\right) & \cdots & \cdots & \left(\frac{IS_{mn}}{L_{mn}}\right) \end{pmatrix} \quad \text{.....Formula (1)}$$

And we determined the analysis area as 8x6 chessboard pattern. To quantify the result, we calculated the line and face image sticking value. Normalized data were used for the image sticking value. We used the max and the min value of borderline for the line image sticking and the average value of border phase for the face image sticking. And then, it was calculated the non-uniformity characteristics of the line and face image sticking.

In formula (2) and (3), we gave a definition of "N" as normalized data. We used the max and min value of the boundary for line image sticking analysis. And we used the average value of analysis area for face image sticking analysis.

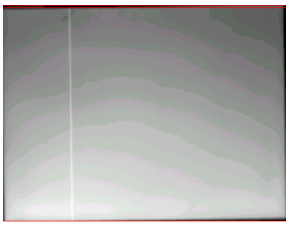
We called ISV_L and ISV_F that mean the image sticking value of Line- and Face-Image Sticking, respectively.

$$Line\_image\_sticking = \left(\frac{N_{\max} - N_{\min}}{N_{\max}}\right) \times 100 \text{.....} formula(2)$$

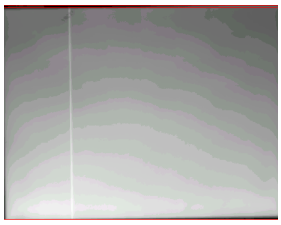
$$Face\_image\_sticking = \left(\frac{N_{average\_\max} - N_{average\_\min}}{N_{average\_\max}}\right) \times 100 \text{.....} formula(3)$$

3. Results

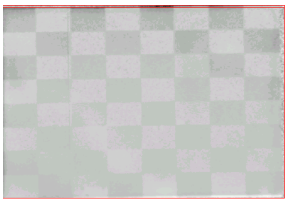
Figures 3 (a) and 3 (b) show the measured images before image sticking test and after image sticking test, respectively. These two figures were tested with the 127gray level pattern. We could not find the image-sticking phenomena after image sticking test (Figure b). But the figure (c) shows the mapping result of normalized data group. And it is so sensitive for image sticking phenomena.



(a) Before image sticking test



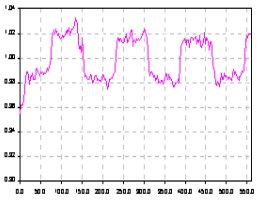
(b) after image sticking test



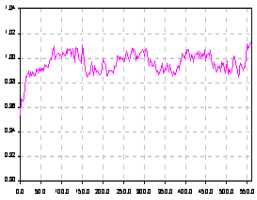
(c)Normalized data set

Figure 3. Image mapping results.

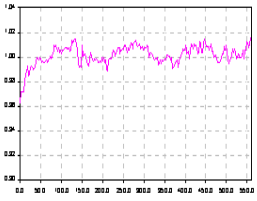
Figure 4 show the horizontal data set from the normalized data group Figure 3 (c).. We could find the image-sticking phenomena; it means that the gap of high level and low-level peak shows image-sticking phenomena. And then, we calculated the image sticking value of each area, we defined that the non-uniformity factor of each area is image-sticking value.



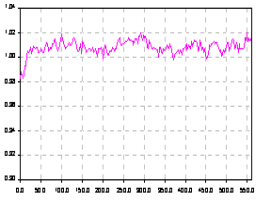
(a) Strong level



(b) Middle level



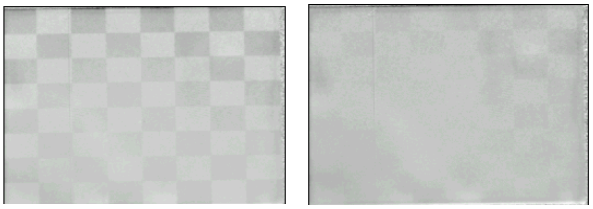
(c) weak level



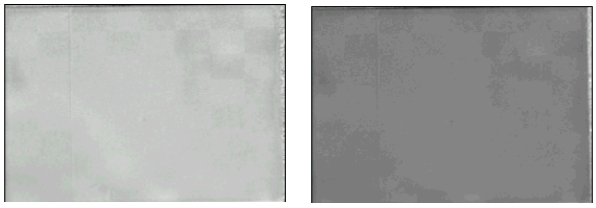
(d) very weak level

Figure 4. Horizontal characteristics of normalized data set

We could order the image sticking level with this result. This result corresponded to human eye testing result. And this result is more accurate than eye test result because of quantifying the measured data.
Figure 5 shows the re-mapping image of normalized data as a level of image sticking.



(a) Very strong level (b) Strong level



(c) Middle level (d) low level

Figure 5. Image mapping result in each level

Table 1 shows the result of face image sticking and Table 2 shows the result of line image sticking value. We have selected seven horizontal area because our image sticking pattern is 8 X 6 chess board pattern. In this result, it tell us the image sticking level in each testing area.

Table1. The result of face Image Sticking

Area	Strong	Middle	weak	Very weak
Area1	3,09	1,62	0,78	0,40
Area2	2,49	0,96	0,62	0,42
Area3	2,01	0,16	0,11	0,03
Area4	2,37	0,93	0,69	0,41
Area5	3,05	1,47	1,18	0,82
Area6	3,51	1,87	1,63	1,49
Area7	4,26	2,98	2,57	2,06
Average	2,97	1,43	1,08	0,80
max	4,26	2,98	2,57	2,06

Figure 6 shows the face image sticking value of each area with the average image sticking value. And figure 7 shows the line image sticking value with min and max image sticking value.
As the result, if the face image sticking value is below 1%, inspector could not find the image-sticking phenomenon. When the results are 1~2%, we can recognize the image sticking phenomena.
To quantify this result, we calculate the image sticking value. The level of this table strong, middle, weak, very weak- determined by inspector.

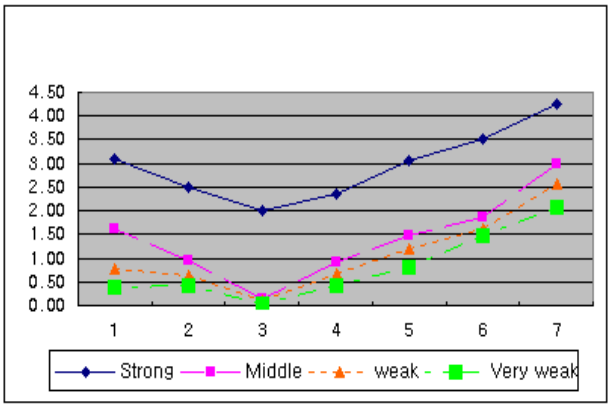


Figure 6. The result of face image sticking

Table2. The result of line Image Sticking

Area	Strong	Middle	weak	Very weak
Area1	2,61	1,70	0,97	1,30
Area2	3,11	1,06	0,85	0,86
Area3	1,98	1,38	0,20	0,32
Area4	2,31	0,79	0,74	0,42
Area5	3,16	1,41	1,65	1,03
Area6	2,01	0,64	0,34	0,10
Area7	3,31	1,74	1,78	1,92
Average	2,64	1,25	0,93	0,85
max	3,31	1,74	1,78	1,92

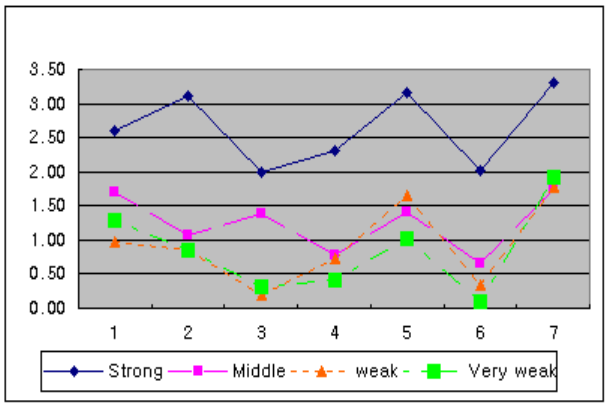


Figure 7. The result if line image sticking

This shows that our result is a tendency to equal, with human eye testing result. And this method is more quantitative than human eye testing method. In human eye can distinguish the line and face image sticking phenomena. In this study, our new analysis method can distinguish the line and face image sticking phenomena. And our method is more quantified than human eye test method.

4. Conclusions

We proposed an analysis method for image sticking phenomena and found the quantification of image-sticking phenomena from this method, and classify the image sticking level. This result will help determine the level of image sticking. We expect that this method will help both vendor and supplier solving the image-sticking problem.

But this result is an output of some experiment. We need more optical experiment and human eye test for using in industry. And this study includes only the image sticking. Therefore we will study other stain phenomenon for objective evaluation of display. We think that these studies will help the developing of ergonomic evaluation method. And the inspection of FPD image quality has been sensory, mainly conducted via the human eye there has been no common analysis method for image sticking level. Because of this absent of the analysis method or standard of evaluation, when panel makers and their users who conduct business with a fixed quality level set an image quality acceptance level, limit samples are used as necessary and some products are over killed by visual inspection with human eye.

Above all, in the industry there is no fixed analysis or evaluation method for expressing image sticking level. In fact, human eye is sensitive more than optical equipment. But human eye is weak in quantified measurement. Therefore, we will try to study about quantity of image quality. And we think that these studies help to many manufacturers and end users.

5. References

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