Rubbing Process Evaluation Method for The LCD Panel

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Abstract
In order to realize a stable rubbing process for the liquid crystal panel, the authors investigated the quantitative evaluation method of rubbing process uniformity. The proposed method focuses on the relationship between the image quality of the LCD panel for gray scale images and the rubbing uniformity. The proposed method indicates rubbing uniformity using quantitative parameters of spots and hairlines on the LCD panel.

1. Introduction
Applications of LCD panel, which is a key component in liquid crystal displays, have become increasingly widespread. As a result, the development of stable mass production technology has become exceedingly important.
The assembly process of the glass substrates greatly affects the quality of the liquid crystal panel, and the rubbing process, shown in Figure 1, is one such process. The polyimide layer on the glass substrates is alimented via a cloth-covered rotating roller. It is very important for the polyimide layer to be rubbed evenly. Uneven rubbing causes uneven anchoring energy dispersion, which causes brightness spots to form. Accordingly, in order to maintain the high quality of the LCD panel, visual inspection, which is a labor-intensive process, is required just after the rubbing process. This process is very important in order to develop quantitative methods. The quantitative method for image quality of the LCD panel has been investigated in numerous studies[123].
However, LCD panel image quality has improved rapidly, and the demand for innovative image quantitative methods, particularly gray scale image quantitative methods, has increased. Previous studies[4] were adaptable for the inspection process for the period before glass substrates assembly; however, this was not the case for the rubbing process.
Accordingly, the authors attempted to develop a quantitative method for the rubbing process by focusing on the relationship between the image quality of the LCD panel and the rubbing uniformity.

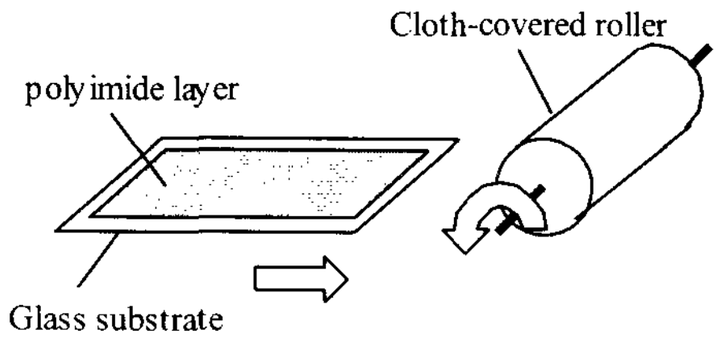

Figure 1 Rubbing process for the LCD Panel

2. Experimental method and apparatus
The presence of brightness spots and hairlines has been confirmed in unevenly rubbed LCD panels. We therefore attempted to realize quantification of the rubbing process by realizing spot and hairline quantification. Figure 2 shows a schematic diagram of the experimental apparatus. In the present study, we utilized the ITO coated glass substrate panel, without TFT array, for the evaluation panel, because of its high sensitivity for subtle rubbing unevenness.

The image of the luminous plane of the LCD panel, which is illuminated by backlighting, is captured by

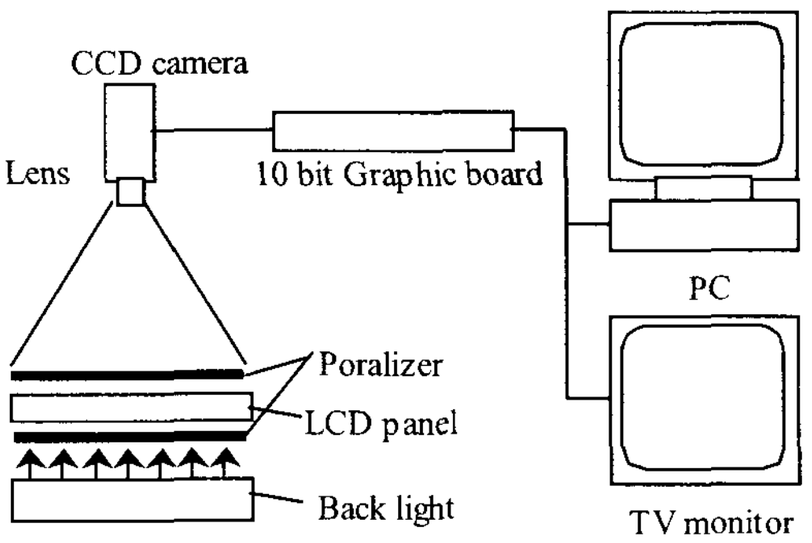

Figure 2 Schematic diagram of the experimental apparatus

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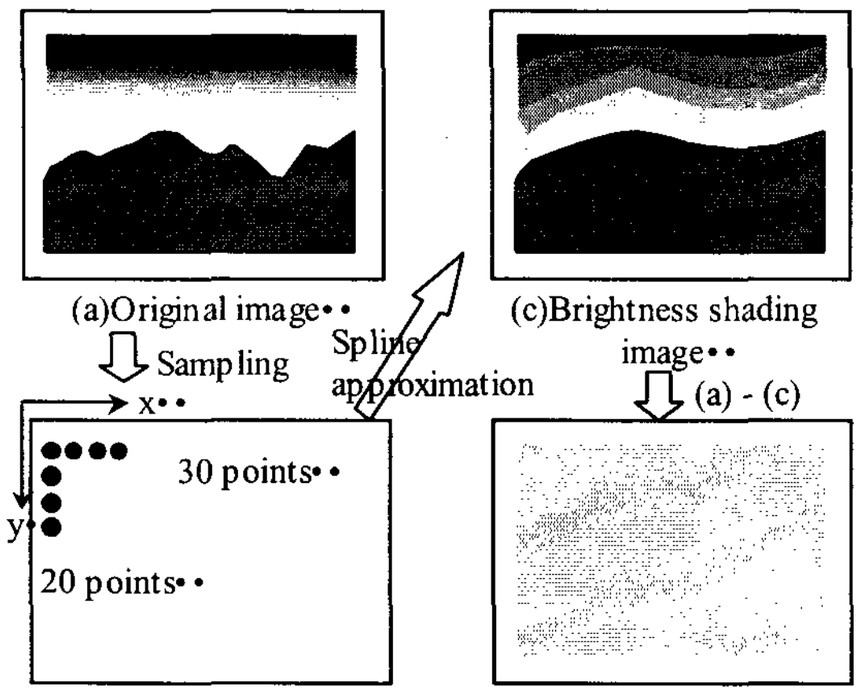


Figure 3 Brightness shading elimination method

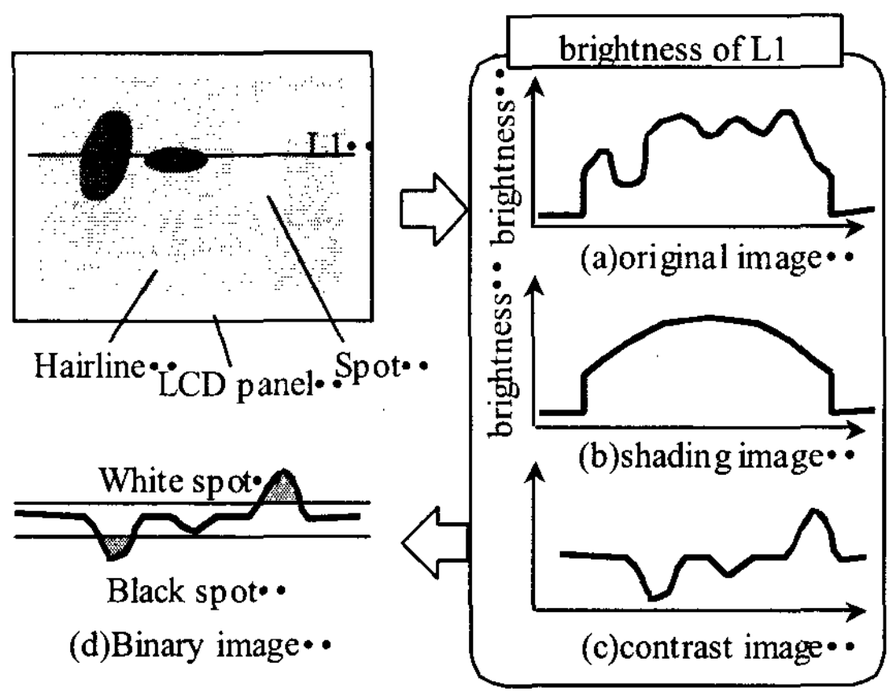


Figure 4 Binary procedure for contrast image

CCD camera, and the rubbing process evaluation method was examined using the acquired video image. We used a 10-bit graphic board for image acquisition and decreased random noise by 64 times via additional image processing. We defined the image-processing size as 640X480.

A unique brightness shading, which depends on the field of view of the LCD panel, existed in the original image of the luminous plane of the LCD panel, as shown in Figure 3. This brightness shading interferes with the detection of subtle brightness spots. Therefore, we eliminated the brightness shading by the following process.

First, 600 data points (x-direction 30 points, y-direction 20 points) of the original image were sampled at a fixed distance. Next, using the brightness value of the sampling points, we generated a curved line via spline approximation[5], and compensated for the exception data for the sampling points.

These procedures generate a brightness shading image, as shown in Figure 3(b). Finally, after eliminating the brightness shading based on the difference between the original image and the brightness shading image, we obtained the difference image, in which only subtle spot images exist. The evaluation image shown in Figure 3(c) is obtained by dividing the differential image by the brightness shading image.

3. Spot and hairline quantitative method

3.1 Quantitative parameter of the spot

We attempted quantitative evaluation based on the concentrations and areas of the spots. Figure 4 indicates the processing by which quantitative evaluation of the spots was performed, using a point on line L1 as an example. Brightness shading appears on the LCD panel as a result of the dependence on the field of view.

The differential was calculated between the brightness shading indicated in Figure 4 (b) and the original image shown in Figure 1 (a), and this value was then divided by a standard value in order to obtain the contrast image indicated in Figure 4 (c). Then, using the contrast image of Figure 4 (c), all sections having values higher than a certain threshold value were identified as "white spots" and sections below the threshold value were identified as "black spots".

Next, in order to place the candidate spots that had undergone binary processing in the same field as the consecutive pixels, labeling processing was performed. Through this processing, calculation of the mean contrast value and the surface area of each of the individual spots that had been identified was possible.

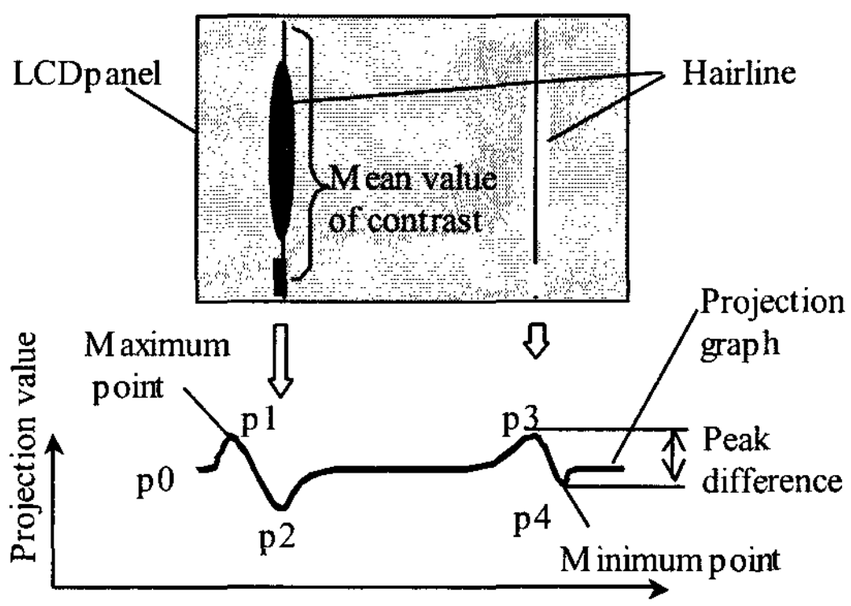


Figure 5 Hairline quantitative method

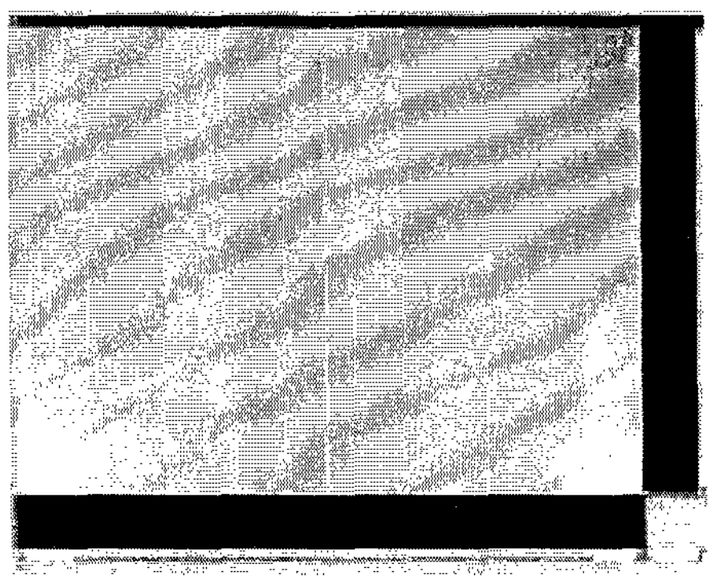
3.2 Quantitative parameter of the hairline

For the hairlines, we attempted to perform quantitative processing focusing on the concentration and number of hairlines. The hairlines had a low contrast level, but were characterized by consecutive appearance in a given direction. The method by which quantification was performed is described in Figure 2.

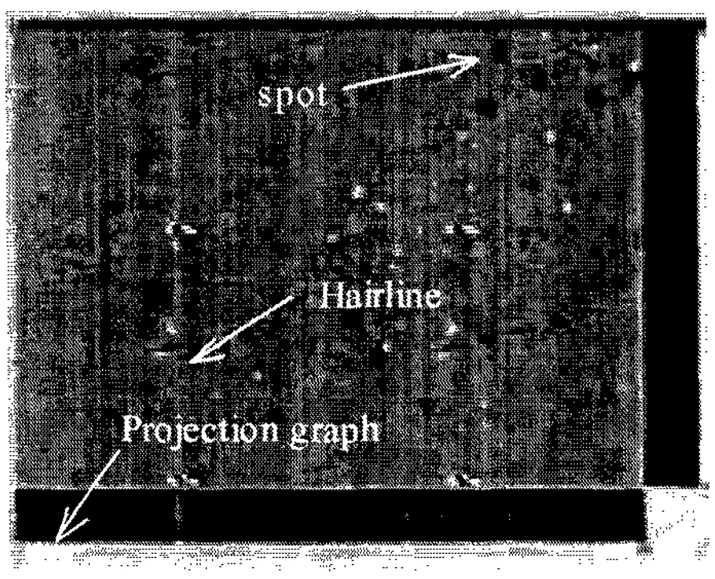
First, using the same procedure as that used for quantification of the spots, we determined the contrast values for all of the pixels in the LCD panel evaluation image. Next, we determined the mean for the contrast values of all of the pixels in each line in the shorter direction of the LCD panel, and defined that value as the projection value. We then took this projection value as the moving average, and created a projection graph. The maximum and minimum points on the projection graph were determined and were defined as the contrast values.

As a result, the projection contrast obtained using the following equation was used as the index to indicate the concentration of the spots.

$$Projection\ contrast\ (\%) = \frac{p_i - p_{i-1}}{p_0} \times 100 \quad (1)$$



(a) Original image



(b) Contrast image

Figure 6 Result of performance confirmation (15"LCD panel)

3.3 Evaluation of the proposed method

Figure 6 shows the results of the performance confirmation test conducted in the above-described procedure. Figure 6(a) is the original image described in Figure 3(a). Figure 6(b) is a contrast image, containing spots and hairlines that are difficult to see using the naked eye. In addition, evaluation of the quantification of the hairlines was possible using the projection graph.

4. Conclusion

In order to achieve a quantitative evaluation of the rubbing processes, a quantitative method was developed for gray scale images. The proposed method focuses on the spots and hairlines displayed in an LC panel that arise due to non-uniform rubbing. It enabled a quantitative evaluation of the rubbing processes without regard for an LCD panel size and glass substrates size.

5. Acknowledgements

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6. References

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