A Study on Local Dimming Algorithm Design for MINI LED Backlight Display Quality Improvement. †

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Abstract

Today HDR (High Dynamic Range) Displays are increasingly developed. The HDR Display with mini-led backlight and liquid-crystal panel plays an important role, it has a lot of advantages like high light (more than 1000nits), high contrast ratio (more than 100000:1), bright color and good permeability and so on. But it also has some display defects like halo[3] phenomenon in a dark scene. In this paper, first, we discuss some common picture quality issues caused by the normal local dimming algorithm[2] and then present a novel algorithm base on BOE COG (chip on glass) mini-led backlight HDR display. The BOE COG technology is a global unique glass substrate backlight solution, and has some features to help the algorithm improve its performance. And for the local dimming display issues, the algorithm itself has room for optimizing visual effects. Finally, around the key point of local dimming algorithm, we show several advantages of BOE glass substrate backlight solution, its distinctive features can help the algorithm improve picture quality.

Author Keywords

HDR display; MINI LED; local dimming algorithm; glass substrate backlight solution; hardware-defined algorithm.

1. Introduction

In recent years, with the development of mini led manufacturing technology, the HDR display product's backlight unit with small partition size and large partition number gradually become the mainstream, the local dimming control also has become one of the remarkable techniques because both high peak brightness and high contrast ratio can be expected. With the more local dimming zones designed (1K-10K), the product will get fine HDR quality picture and less halo.

Figure 1 shows the monitor product using BOE glass substrate backlight solution. Which has 1152 zone design and peak luminance is 1000 nits. Through HDR source display, product display a perfect picture quality.

Figure 1. 34inch 1152zone HDR Display.

The local dimming control algorithm is the critical factor to display quality with the improvement of local dimming display hardware parameters. Some traditional algorithms and some "cost-down" algorithms are not suitable for the high quality display, because the local dimming zone partitions are more delicate and the zone light pattern is sharper. Compared with the previous rough partitioning, the algorithm has the ability to further improve the picture quality for HDR display.

Figure 2 shows a schematic of local dimming algorithm[1]. From the traditional liquid crystal controlled light display to backlight partition controllable. We can see that the optical properties of the backlight partition are overly smooth, the image formed by the backlight is a blurry picture. The fewer pixels each partition contains, the less impact each partition has on other partitions, and the clearer the backlit image will be, thus improving the local contrast of the image display. In this paper, we focus on how to design the algorithm effect correctly and implement it in the product reasonably.

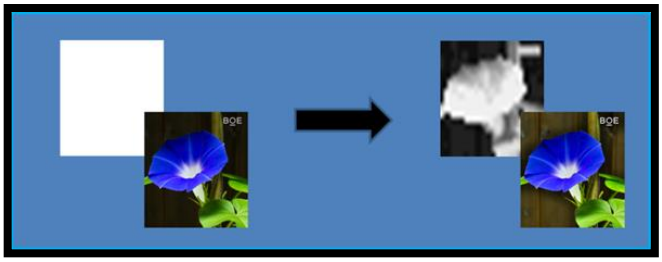

Figure 2. Schematic of Algorithm processing.

2. Algorithm

Overall Scheme: Figure 3 shows a normal overall scheme of the local dimming algorithm. For the hardware design of the algorithm, it adopt a pipeline design architecture. By partition data statistics and operations, the input image is split into backlight output zone data and liquid crystal output image pixel data.

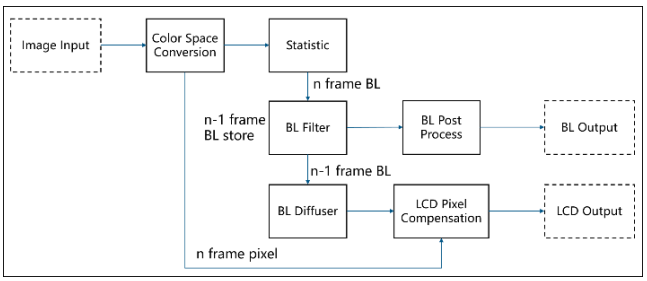

Figure 3. Overall scheme of Local-dimming.

As mentioned above, the picture effect is directly determined by the backlight data and liquid crystal data. And the data is determined by local dimming algorithm, but local dimming does not simply implement optical splitting. The algorithm needs to consider the point diffusion shape of the zone light, the performance of highlight and halo, and the loss caused by hardware design. Algorithms like reference[4] can get better statistic data, but it is difficult to implement hardware because of the complexity of the iterative operation. Based on the above views, we summarize three key design elements and discuss how BOE COG backlight and algorithms can improve picture quality of the MINI LED HDR display. The three main points are matching design, halo effect improve and display fidelity.

Matching Design: The partitioned control of the backlight gives the HDR display another dimension of dimming capability. Another dimension of light control is the liquid crystal display data. Therefore, the design match between the two is very important for the display effect. We have divided this topic into three parts, include matching of partition features, matching of color and brightness, and matching of partitioned optical patterns.

The first point, here is a common fact that's easy to miss, the partitioning of pixels is based on the optical partitioning. We did a test like figure 4 below. Light up part of the partition, draw some white lines base on two different partition modes. Left is an average by pixel number, right is follow the physical dimensions of the partition. As we can see, since the edge LED zone is closer to the AA area (less than led pitch), the size of the most edge partition is different from that of the middle partition. So when the error accumulates, the actual partition on the left is straddled between the partitions that are evenly divided by numbers. This kind of incorrect calculation will result in the need for more smoothing in the algorithm to compensate for the errors caused by inaccurate partitioning.

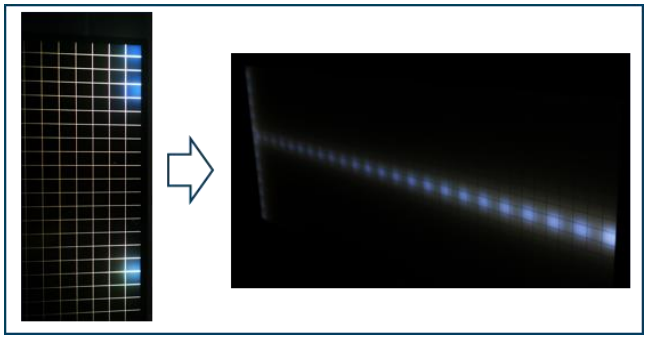

Figure 4. Example of Matching of Partition Features.

The second point, involves gamma and color coordinates. It is relatively simple, LCD's usual gamma is set to 2.2 and LED's gamma is set to 1.0. If the gamma shift, it can be corrected by backlight LUT or algorithm LUT. The final optical effect is a superposition of the two. The formula relation is shown as below. In another aspect, if the LED color offset, display can be compensated by liquid crystal RGB data ratio.

$$display = (V_{BL})^{\gamma_{bl}} \times \left[(V_{LC})^{\gamma_{lc}} \times (LC_{\max} - LC_{\min}) + LC_{\min}\right] \quad (1)$$

The third point, the backlight partitioned optical pattern is usually said to be backlight partition point spread function curve. Consider the cost performance of the algorithm design, traditional algorithms usually use filtering or interpolation processing method. When the backlight zone area is large and the data is smooth design, there were no apparent visual problems, but this will result in a lack of contrast and a large halo. When we want to refine the control of the backlight, the problem shown below will occur. The pattern on the left show the problem of inaccuracies compensation. The pattern on the right show the ideal display case.

Figure 5. The Problem of Inaccuracies Compensation.

With the development of Mini LED technology, local details and contrast can be improved. Figure 6 shows the backlight zone optical point spread function is obvious optimization with the increase of the number of partitions. As optical patterns become sharper, refined optical control algorithms not only improve performance, but also reduce the hardware cost of storing optical patterns.

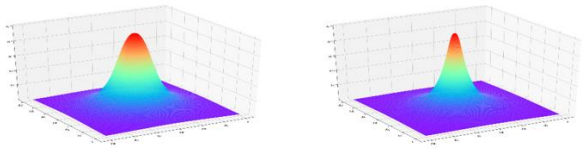

Figure 6. 27 inch 576 zone & 5184 zone comparison.

Under normal conditions, the light pattern of the partition is assumed to be a cone uniform in all directions. But in actual applications, the light type depends on the pitch of the LEDs, like data in figure 7, the light pattern is more like an oval than a circle. This information can also be taken into account in algorithm design to refine dimming treatment. It also reduces the spread and smoothing of the halo.

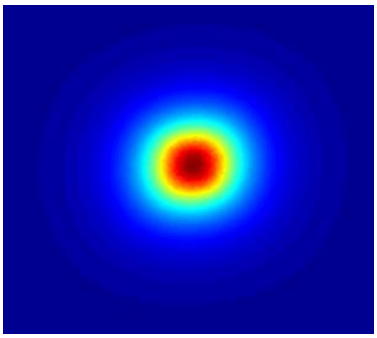

Figure 7. Optical Data of Local Dimming Zone.

Halo Effect Improve: Halo optimization is the most important part of local dimming algorithm design. Figure 8 shows our improvement in the halo treatment effect, the left is the optimized effect, the right is the conventional algorithm. An important algorithmic problem affecting halo is the smoothing of partitioned data, a good algorithm can not only meet the brightness and data expression, but also into account the halo and flicker problems.

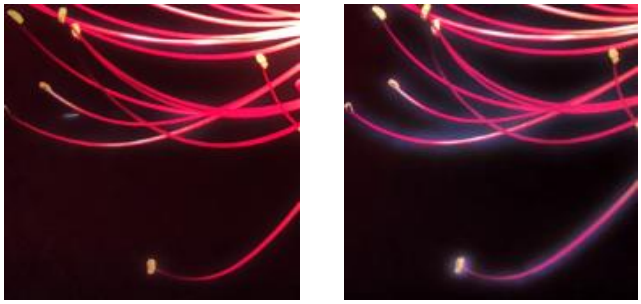

Figure 8. Halo Effect Improve.

Display Fidelity: We believe that the first two problems are the dominant problems brought by the light-emitting devices themselves. What is more important is how to better display and restore HDR source content. The problem, as shown on the left, is the loss of detail caused by the compensation overflow. This is usually associated with under assigning the backlight value. The scene shown on the right is usually prone to flicker, usually associated with the backlight changing too quickly between frames.

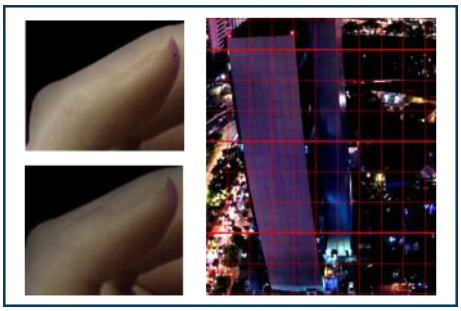

Figure 9. Other Display Problem.

3. Mini LED Topic

BOE Mini LED is a global unique glass substrate solution. Have perfect picture quality, fashion design, healthy drive and high reliability and so on many advantages. The performance is shown in the following figures.

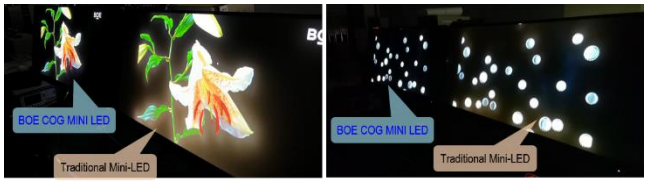

Figure 10. BOE Mini LED MNT Performance.

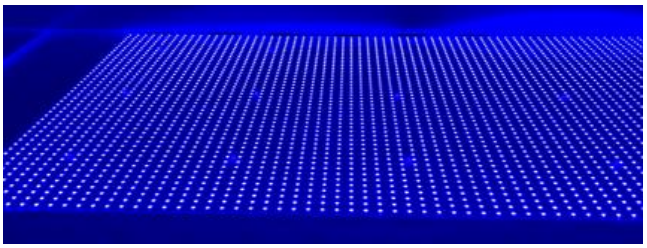

Figure 11. Glass Substrate Backlight.

The glass substrate backlight is a single light board design, which can reduce the misalignment cause by stitching. That will help the matching design and reduce the no necessary smoothing filer to reduce the halo. And the glass base product can make higher partitions. This will promote the local contrast improvement of the algorithm and help halo effect improve. Along with the refinement of backlit partitions, it also help display fidelity. On the other hand, the glass flatness is very high (≤0.1mm), and has no deformation because of the high reliability. This makes the algorithm more concise and can handle dimming more effectively while reducing the halo loss cause by data smoothing.

4. Conclusion

This paper analyzes the causes of local dimming common problems. Summarize the local dimming algorithm design key point which can help to improve the display quality. At last, the advantages of BOE glass base are introduced. We believe that through the combination of software and hardware, we can achieve further quality breakthroughs.

5. References

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