Image Sticking Compensation of MLED Splicing Screen based on Temperature Sensor Perception

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Abstract

The display consistency is affected by temperature difference sticking image of MLED splicing screen. We propose a compensation method based on temperature sensor perception. Through structural improvements and temperature perception by the sensors, precise real-time image sticking compensation is achieved, significantly enhancing the luminance and chroma consistency of MLED splicing screens. The method is deployed using FPGA and has been integrated into product mass production.

Author Keywords

MLED; Image sticking; Temperature sensor; Consistency compensation

1. Introduction

MLED Advantages: MLED refers to both Mini LED and Micro LED technologies, and it has the following advantages: high luminance and high contrast, high resolution, long lifespan and low power consumption, fast response time, and efficient transmission.These advantages make MLED technology highly competitive and have broad application prospects in the display field.

Cause of image sticking: The issue of image sticking in display panels has been a long-standing problem, affecting LCD(Liquid Crystal Display, liquid crystal display) , OLED(Organic Light Emitting Diode), and MLED(Mini/Micro Light Emitting Diode) technologies. The main causes of image sticking in LCD include the characteristics of liquid crystal materials, response time issues, aging of liquid crystals, afterglow effects of the backlight source, and abnormal driving voltage. For OLED, the reasons for image sticking include the characteristics of EL (electroluminescence) materials, threshold voltage drift in TFTs (Thin Film Transistors), and uneven temperature distribution.

The causes of image sticking in MLED mainly include the following points: high temperature affecting the efficiency of red light emission, temperature differences causing full-screen gray image residuals, and local overheating issues. In summary, temperature is the primary factor causing MLED image sticking. This article focuses on the MLED image sticking issues caused by temperature[1-4].

Figure 1. The thermal map formed by the lighting pattern of MLED splicing screens.

Analysis of existing compensation techniques: MLED technology has significant advantages in the display field, but image sticking has always been one of the key factors affecting its display quality. Existing compensation schemes based on the history of cumulative images and screen temperature characteristics estimation have limitations and cannot accurately adapt to the dynamic changes in actual screen temperature, leading to unsatisfactory compensation effects [5]. To address this issue, an improved method is proposed by incorporating temperature sensors to collect real-time temperature of the current MLED screen, thereby enhancing the precision and effectiveness of the image sticking compensation.

2. MLED splicing screen structure optimization

(a) Temperature sensor scheme design

Selection and arrangement of temperature sensor: We choose a high-precision thermistor temperature sensor, which has the advantages of high sensitivity, fast response speed and relatively low cost, and can meet the requirements of MLED screen temperature monitoring.

According to the structure and heating characteristics of the MLED screen, the temperature sensor is rationally arranged. Temperature sensors are set in different areas of the screen, such as the center, edge, corner, etc., and near different heating elements (such as LED chip dense areas), in order to comprehensively and accurately monitor the distribution of screen temperature. Through the cooperative work of multiple sensors, more detailed temperature information can be obtained, which provides a basis for accurate image sticking compensation.

Temperature data processing: The temperature sensor collects the temperature data of the MLED screen in real time and transmits it to our image sticking compensation algorithm. Our algorithm reads temperature data at a high frequency of 1 time per second to achieve real-time tracking of changes in screen temperature.

Noise interference in temperature data is removed by filtering algorithm to ensure the accuracy and stability of temperature data. At the same time, according to the distribution position and measurement value of the temperature sensor, the average temperature of the screen, temperature gradient and other parameters are calculated through the algorithm, in order to understand the state of the screen temperature more comprehensively.

(b) Soaking system

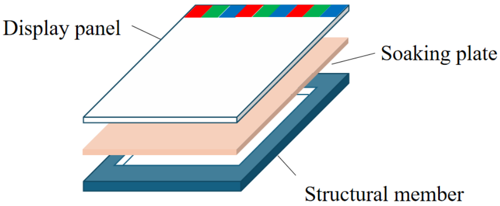


Figure 2. MLED unit screen soaking structure.

Soaking board has an important impact on the temperature consistency of the display panel, mainly in the following aspects:

Improve the uniformity of temperature distribution:

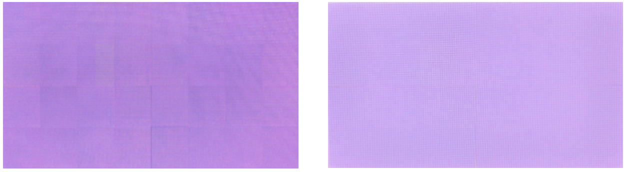
The soaking plate makes the local high heat on the display panel quickly dispersed to the whole soaking plate, and then the heat is dissipated through the heat exchange between the soaking plate and the outside world, thereby reducing the temperature difference between different areas of the display panel and improving the uniformity of temperature distribution.

Enhanced temperature stability: The thermal response speed of the soaking plate is very fast, and when the heating condition of the display panel changes, the soaking plate can quickly absorb or emit heat to maintain the temperature stability of the display panel. In the case of external ambient temperature changes or the display panel's own heating is uneven, the soaking plate can play a buffer role, reduce the impact of temperature fluctuations on the display panel, so that the temperature of the display panel remains relatively stable and improves the temperature consistency.

Improve the display effect: the temperature has a great impact on the color display of the display panel, and different temperatures will cause the color output of the display panel to deviate. By maintaining the consistency of the temperature of the display panel through the soaking plate, the chroma deviation caused by the temperature difference can be reduced, so that the display panel can present accurate and consistent s in different areas, and improve the display quality.

(c) Screen consistency correction

The MLED splicing screen needs to undergo several consistency corrections before normal display, and the consistency of the screen before correction is so-so, as shown in the Figure 3:



(1) before consistency correction

(2) after consistency correction

Figure 3. Before consistency correction and after consistency correction

The purpose of consistency correction is to allow the screen to display the corresponding color normally, and it is a prerequisite for ensuring the normal display of the screen. However, the consistency correction of the screen needs to light the pattern of the same gray level on the whole screen, and then carry out the luminance uniformity correction of the pixel of the screen through the luminance and chroma of the screen image captured by the camera. This process often takes several hours, during which time the temperature - chromaticity characteristics of different units of the whole splicing screen are inconsistent.

3. Unit screen temperature - chromaticity characteristic difference

The temperature - chromaticity characteristic describes the chroma performance of the screen at the operating temperature, and theoretically it is a one-dimensional curve.

The main reasons for inconsistent temperature - chromaticity characteristics of different unit screens throughout the screen are:

The position difference of the unit screen in the whole splicing screen leads to the inconsistency of the unit screen temperature at different positions: The MLED splicing screen is usually placed vertically on the ground, so some unit screens are low from the ground and some are high from the ground. When the whole screen is working, the heat will be conducted from below the screen to the top of the screen, resulting in a high temperature on the top screen and a low temperature on the bottom screen. At the same time, because the unit screen at the edge of the whole screen has a larger contact area with the air, it is easier to dissipate heat, so their temperature is often lower than the unit screen temperature in the center of the whole screen.

Consistency correction results in inconsistent temperature - chromaticity characteristics of the unit screen: When consistency correction is carried out, the luminance and chroma of all unit screens will be corrected to be consistent to ensure the consistency of the entire screen display, but it is difficult to ensure the temperature consistency of different unit screens.

As mentioned earlier, different physical locations of different unit screens lead to different temperatures, and after consistency correction, the luminance and chroma of the whole screen tend to be consistent, and the inconsistency of temperature and the consistency of luminance eventually lead to the inconsistency of temperature and chroma characteristics of different unit screens.

(a) Different unit screen temperature characteristics

The temperature of the screen will gradually increase over time. The highest bright white screen is lit through the whole screen, and then the temperature and chroma of each unit screen are measured every 1min until the temperature of the whole screen no longer rises. After statistical processing of the above test data, the whole screen temperature - chromaticity curve described in the following Figure 4 can be obtained, where each curve describes the chroma change of a unit screen from the lowest temperature to the highest temperature.

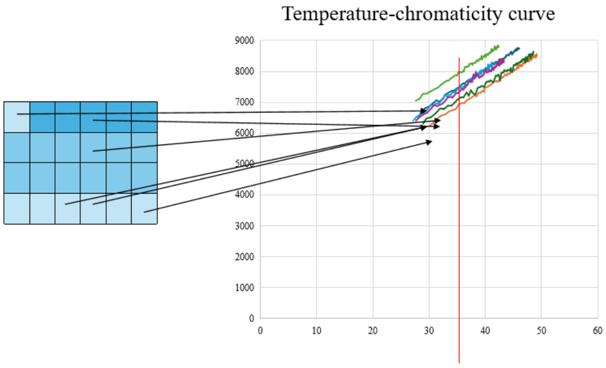


Figure 4. temperature - chromaticity curves for different unit screens

Overall trend analysis: In Figure 4, the horizontal axis represents temperature and the vertical axis represents chroma. With the change of temperature, chroma shows a certain trend of change. Different unit screens show different chroma values at the same temperature, which indicates that each unit screen in the splicing screen has a difference in the relationship between temperature and chroma. This difference may be due to the differences in the manufacturing process, material characteristics, aging degree and other factors of different unit screens. For example, some unit screens may exhibit higher chroma at lower temperatures, while others may have lower chroma at the same temperature. But the main reason is due to the inconsistency between the temperature of the whole screen and the consistency of the luminance.

Limitations of early consistency correction: In the previous consistency correction, only the luminance and chroma consistency of the whole screen display in the stable state was considered. When the consistency correction of the splicing screen is carried out, the chroma characteristics of each unit screen at different temperatures cannot be fully taken into account. The whole screen consistency correction only adjusts the luminance and chroma of the unit screen within a specific temperature range or under a specific working state, and ignores the changes of the unit screen under other temperature conditions. This leads to the fact that in actual use, when the temperature changes, the original corrected luminance consistency is broken, and the luminance is inconsistent.

Luminance and chroma compensation for anomalies based on temperature difference: The different temperature - chromaticity characteristics of different unit screens lead to abnormal image sticking compensation based on single variable of temperature difference. The method of image sticking compensation based solely on temperature difference is not ideal in practical application. A uniform compensation method based on temperature difference cannot be applied to all unit screens.

(b) Unit screen temperature - chromaticity characteristic model

According to the temperature - chromaticity curve data of different unit screens shown in Figure 4, it can be seen that the temperature - chromaticity characteristics of each unit screen tend to change linearly, so the temperature - chromaticity characteristics of the unit screen can be approximately described by a straight line.

By collecting the temperature and chroma data of each unit screen in MLED splicing screen at different times from the lowest temperature to the highest temperature, each unit screen can be fitted to its own temperature - chromaticity characteristic model. In this paper, a linear regression model is used to fit the temperature - chromaticity characteristics of the unit screen. The fitting results for all unit screens of the whole screen are shown in the Figure 5.

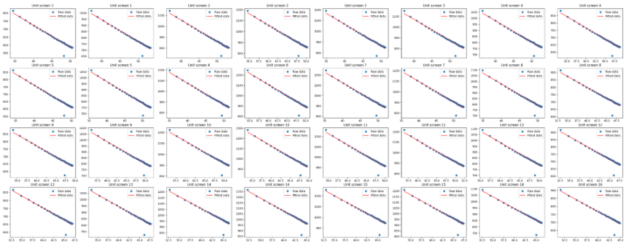


Figure 5. Linear fitting results of temperature and chrominance in different unit screens

4. Image sticking compensation

As shown in the above section, the temperature and chroma of each unit screen basically meet the linear characteristics. The process of calculating the basic compensation value of the screen according to the temperature - chromaticity characteristic model is as follows:

1. Get the current temperature value of each unit screen.
2. Input the temperature value of each unit screen into the corresponding temperature - chromaticity characteristic model to obtain the current chroma estimation of all unit screens.
3. Adjust the chroma through the difference of chroma estimation between different unit screens, adjust the chroma of all unit screens in the whole screen to be consistent, so as to achieve image sticking compensation.

Image sticking compensation optimization based on real-time temperature: Combining real-time temperature and historical accumulated image information, a more accurate image sticking compensation strategy is developed. The historical cumulative image reflects the frequency of use and the degree of aging of screen pixels, while the real-time temperature provides key information about the current state of the screen. By taking these two factors into consideration, the image sticking trend of pixels can be predicted more accurately and corresponding compensation measures can be taken. For example, for areas that display high luminance images for a long time and the current temperature is higher, more substantial image sticking compensation is given; For areas with low temperature and low frequency of use, the compensation intensity can be appropriately reduced to optimize the compensation effect and reduce the system resource consumption.

Advantages and expected effects: By collecting the screen temperature in real time, the actual temperature state of the current screen can be accurately obtained, and the error based on historical data and model estimation can be avoided. This makes the image sticking compensation algorithm can accurately adjust the compensation parameters according to the real-time temperature, and accurately compensate the image sticking problem under different temperature conditions. Combined with the distribution data of the temperature sensor and the historical accumulated image information, the influence of temperature differences in different areas of the screen on the image sticking can be considered more carefully. Thus, personalized compensation for each area of the screen can be realized, and the uniformity and accuracy of the overall compensation effect can be further improved.

5. Experimental and Result

(a) Experimental condition

An MLED whole screen composed of 4×8 unit screen was used for the algorithm experiment, and the resolution of the screen was 1280×720 pixels. The experimental environment is set up in a dark room to ensure the accuracy of the test results. The screen lights up the experimental pattern and then runs for 30 minutes to start the experiment to ensure that the screen reaches a stable state. In order to measure the luminance and chroma of the screen, CA410 colorimeter is selected as an optical test instrument.

(b) Experimental method

9 points in the whole screen were randomly selected for the luminance experiment to ensure the representativeness of the experimental results. First, we obtained uncompensated luminance and chroma results, followed by compensated luminance and chroma results at the same 9 points. By comparing the data before and after compensation, we get a comparison result of luminance and chroma, which will help us evaluate the effect of the image sticking compensation algorithm on the luminance and chroma uniformity of the whole screen. The whole experimental scheme aims to comprehensively evaluate the performance of the algorithm on real MLED splicing screens through accurate optical measurements and data analysis.

Figure 6. experimental pattern

(c) Experimental pattern

As shown in Figure 6, we employ a complex experimental pattern, including different colors, shapes and positions, to fully verify the effectiveness of the algorithm.

(d) Experimental result

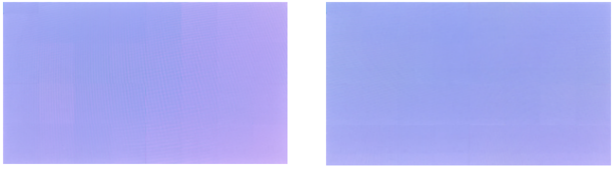
Table 1 shows the experimental data before and after luminance and chroma consistency compensation. The data in the table include two main indicators: delta uv maximum value and luminance uniformity. Delta uv is usually used to measure the degree of chroma deviation, and the smaller the value, the better the chroma consistency. luminance uniformity is used to measure the consistency of the luminance of the screen, and the closer the value is to 1, the more uniform the luminance distribution.

Table 1. Luminance and chroma consistency experimental data before and after compensation

	Before compensation	**After compensation**
delta uv maximum value	0. 0065	**0. 0019**
Luminance uniformity	0. 9452	**0. 9749**

As shown in Table 1, before compensation, the maximum value of delta uv is 0.0065, which is reduced to 0.0019 after compensation. This shows that the compensation significantly reduces the chroma deviation and improves the chroma consistency of the screen display. The luminance uniformity in the table is 0.9452 before compensation, and increases to 0.9749 after compensation. This shows that the luminance distribution of the screen after compensation is more uniform, reducing the phenomenon of uneven luminance.

In summary, the experimental data before and after compensation show that the compensation algorithm can effectively improve the luminance and chroma consistency of MLED screen, making the display effect more stable and uniform. Significantly enhance the visual experience and meet high quality display standards.



(1) before compensation (2) after compensation

Figure 7. (1) Display effect before compensation (2) Display effect after compensation

As can be seen from the subjective display effect comparison between (1) and (2) in Figure 7, there are obvious differences in luminance and chroma in different positions in the display effect before compensation. In the display effect after compensation, the luminance and chroma of the whole screen tend to be consistent.

6. Implementation based on FPGA

FPGAs (Field Programmable Gate Arrays) have a highly parallel architecture that can handle multiple tasks simultaneously. In this paper, the MLED image sticking compensation algorithm based on temperature sensor realizes real-time processing by FPGA. The image data is temporarily stored in the buffer after entering the system, the clock provides the synchronization signal for the whole system, and the logic control module is responsible for coordinating and controlling the operation of the whole system. The data processed and stored by the image sticking compensation module is output through the output interface under the coordination of the logic control module.

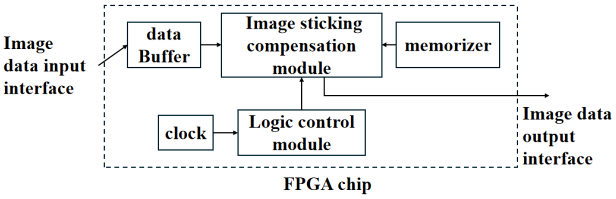


Figure 8. FPGA implementation framework of image sticking compensation algorithm

7. Conclusion

The proposed MLED image sticking compensation algorithm based on temperature sensor can effectively overcome the defects of existing image sticking compensation algorithm based on historical accumulated images and screen temperature characteristic estimation by adding temperature sensor to collect the current MLED screen temperature in real time. By optimizing the structure of the MLED splicing screen, the consistency of the display in the stable state is improved. In addition, the temperature sensor is used to collect the current screen temperature in real time, and the real-time chroma of each unit screen is accurately calculated by establishing the relationship model between temperature and chroma. Combined with the accumulated historical image information, the accurate optimization of image sticking compensation is realized, and the compensation accuracy and effect are significantly improved. This will not only help improve the competitiveness of MLED display technology, but also meet the needs of users for high-quality displays.

8. References

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