Image content adaptive color breakup suppression for field sequential color displays with mini-LED backlight enabled by deep learning

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Mini-LED is an LCD with a size of 0.1-1mm. The LCD with mini-LED backlight is called mini-LED LCD[1]. Mini-LED is a combination of the advantages of LCD and OLED. It has the advantages of high contrast, durability, thinness, and low power consumption. Therefore, it is widely used in Ipads, laptops, TVs, and other devices. Mini-LED LCD is the best display commercially available today. However, due to the color filter, it has the same 2/3 loss of light efficiency as common LCD. If the color filter can be removed, the three sub-frames of RGB can be quickly flashed through time color mixing, a color image will be formed on the retina due to the persistence effect of the human eye. Such a display is called Field Sequential Color Display (FSC-LCD). The FSC-LCD with mini-LED as the backlight maintains the inherent advantages of mini-LED while having three times the brightness and three times the resolution. These advantages make FSC-LCD with mini-LED as the backlight have a broad application prospect in VR/AR/car display and other fields. But it also has a significant shortcoming. When the human eyes and the display move relative to each other and the speed reaches 120° per second, high saturation RGB stripes that reduce the image quality will be observed. This phenomenon is called Color Breakup (CBU).

In order to solve the CBU phenomenon in FSC-LCD, it is necessary to increase the refresh rate of FSC displays above 540Hz, which is currently difficult to achieve. Therefore, researchers have proposed a series of algorithms (Stencil, LPD, Edge, etc.) to suppress CBU at low display refresh rates[2]. Although these algorithms can effectively suppress CBU, they have a significant shortcoming. These algorithms are only applicable to part of the image and cannot guarantee that the CBU in all areas of an image is minimized.

In order to ensure that the CBU in all areas of the image can be minimized, we propose the Deep Learning Field Sequential Display (DL_FSC) algorithm. The DL_FSC algorithm can dynamically select different FSC algorithms to calculate the backlight for each dimming block. Deep learning can automatically match the most suitable FSC algorithm for each dimming block[3]. The development of CBU evaluation standards also makes it possible to generate a large number of training sets quickly[4]. At the same time, the ultra-fine partitions brought by mini-LEDs also make the algorithm of deep learning to match each dimming block more accurate, so CBU is further suppressed(Fig. 1).

Next, verify the performance of DL_FSC suppressing CBU(Fig. 2). Under the 2304 blocks, 25 pictures are used for testing. The horizontal axis represents five FSC algorithms (RGB, LPD, Stencil, Edge, DL_FSC). The vertical axis represents the CBU distribution of 25 pictures. It can be found that the data distribution of the DL_FSC algorithm is the lowest among the five algorithms, so it has the best effect on suppressing CBU.

The DL_FSC algorithm combines the advantages of mini-LED and deep learning. It dynamically calculates the FSC backlight signal to ensure that the CBU is minimized in all image areas. The FSC-LCD with mini-LED as the backlight has the advantages of high contrast, low power consumption, thinness, durability, triple resolution, triple brightness, and ultra-low CBU. It is an ideal display for the next generation.

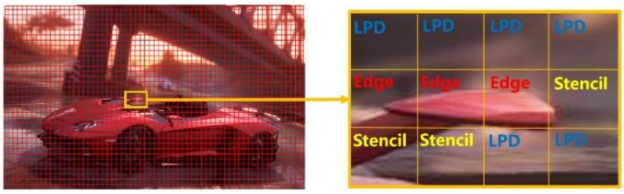

Fig. 1. Mini-LED FSC-LCD has thousands of backlight blocks using the dynamic FSC algorithm

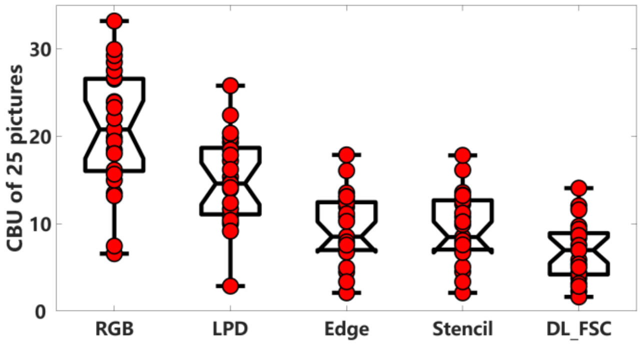

Fig. 2. Comparison of DL_FSC algorithm with current algorithms

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