An Advanced TV Program Logo Processing Algorithm for Preventing OLED TV Image Sticking

Lin Cheng, Yang Rao, Yufeng Jin, Yin-Hung Chen, Ming-Jong Jou, Bin Zhao, Xin Zhang

Shenzhen China Star Optoelectronics Technology Co., Ltd., Guangdong, China
National Engineering Laboratory for AMOLED Process Technology
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ABSTRACT

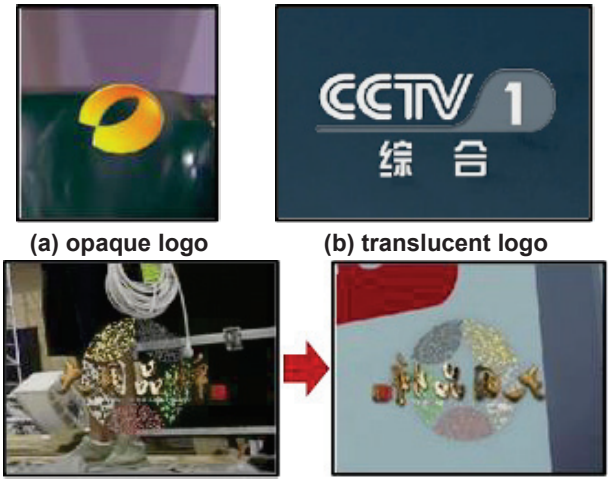
In this paper, a TV logo post-processing system is proposed to relieve the burn-in phenomenon on OLED TV. It contains generic logo detection algorithm and identification mechanism to adapt to video real-time processing and temporary channel change events. With the logo restrain function, OLED TV image-sticking phenomenon would be alleviated.

1. INTRODUCTION

OLED devices [1] require sustained efforts to improve the OLED lifetime due to a characteristic that the luminance degradation with time. The root causes of image-sticking problem is the long-time static image which lead to high difference of aging and result in ghostly appearance on the display even after the display restarted. To solve the problem, logo detection and luminance control method play a key role to ensure OLED image quality. According to the feature of TV logo that displays with high brightness and continuous appearance in same place, logo detection can be applied to localize the operating region of burn-in protection algorithms. TV program logos can be classified into several types based on its motion and transparency characteristics. This paper only considers the common opacity and translucency. Figure 1 shows an example of various types of TV logos.

According to the literature, it's difficult to identify the outline of the logo accurately, which may lead to obvious contour noise or unnatural contour. It's also very important to have robust anti-jamming function, and should take the practical application of TV into account, such as TV program switching or temporary logos fade-in/fade-out and other application situations.

Considering the premise of less hardware resources, this paper proposes a method that divides one frame into several given regions according to the characteristics of the domestic logo. In order to improve the ability of anti-jamming function, this paper proposes three methods that provide better robustness: a luminance restrain method with consistency for human eye perception, a new smooth transition mechanism for TV channels switching, and an inertial detection mechanism for signal flicker in video streams.



(a) opaque logo (b) translucent logo

(c) animated logo

Fig. 1 Example of various logos.

2. LOGO EXTRACTION FUNCTION

There are many conventional methods with its own characteristics. Inter-Frame Difference Method [2], which calculates the difference between Max and Min value in the video flow, the logo area must have less difference. But this method has poor effect in translucent logos detection because the value of the logo area changes with the background content. Contour Invariance Method [3], which uses intra-frame edge detection and average the gradients of N frames. There will be stable edges in logo area, but it has poor effect in low quality signal sources because of the 3D random noise.

Video Frame Weighting Method [4], which average the value of N frames, according to nature films and regular video data, areas other than the logo area will have smaller values. This method can effectively detect both the opaque and translucent logos with complex background changing over time, and logo area obtained by this method has highly stability, which can guarantee the proper extraction of the subsequent logo. By this way, this method can suppress noise and detect the logo more accurately.

In this paper, Video Frame Weighting Method is considered as a better function to the whole system.

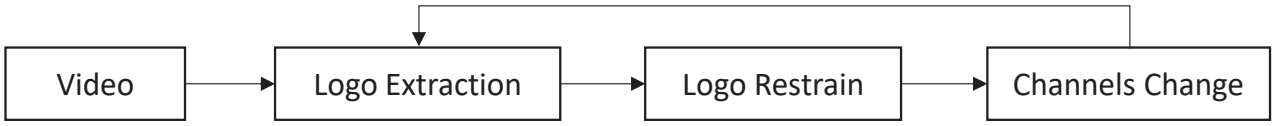


Fig. 2 Procedure diagram of the proposed algorithm.

Fig. 3 The effect diagram of the proposed algorithm.

3. ADVANCED PROCESSING SYSTEM

3.1 Overall Framework

As shown in figure 2, this is the flow chart for logo detection and restrain system. With N frames of the input video stream, TV program logo is detected by Video Frame Weighting Method in real-time. Then the brightness or saturation of logo will be changed to adjust the background. Meanwhile, the logo mask will be verified in every frame, once the TV channel changes which means the logo mask changes, the system triggers a redetection mechanism that makes the logo extraction and restrain function restarted. Figure 3 describes the whole system flowchart and relative results.

3.2 Video Frame Divided into 9 Regions

Most of the channel logos would display at the corners of the screen. One of the novelties of this paper relates to the definition of image regions. The existing technology divides the frame horizontally and vertically by 3:5:3 ratio shown in figure 4a with labeling the regions from 1 to 9 by raster scanning from top left to bottom right. Logos should be appears only in regions 1, 3, 7&9. According to the domestic TV display characteristics, the regions 4 and 6 may also have logo occasionally, mostly are introducing episodes in the current TV series, the partitioning methods has revised as demonstrated in figure 4b. The width of region 4&6 is half as before. It's enough to cover the entire logo. For ease of addressing, the mosaic structure on the right is used. Eventually, it can be guaranteed of accurately detecting all logos with less hardware resources as possible.

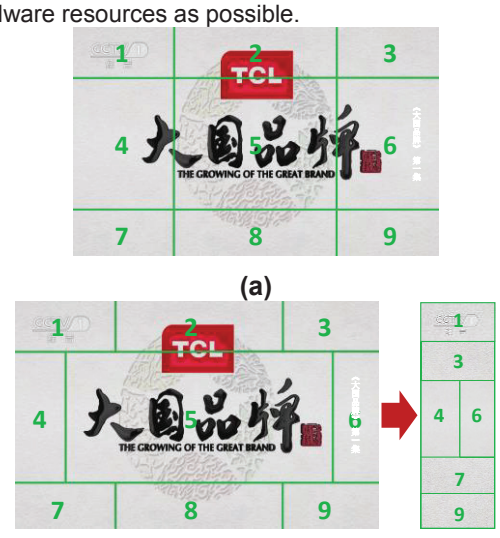


Fig. 4 (a) 3:5:3 spatial division of the frame by GSR. (b) The proposed spatial regions.

3.3 Logo Restrain Function

This paper presents a logo restrain method to adjust the logo brightness in real-time according to the changing of background brightness in the current regions [5]. As shown in figure 5a&5b, it describes different logo restrain effect with different background content. If the background is bright, the restrained logo also boosts to be brighter. Otherwise, the restrained logo will be

suppressed to reduce the brightness. While the brightness of the logo approaches the background, the image sticking phenomenon can be alleviated. The formula of logo luminance target can be expressed as equation (1).

$$I_{restrain} = I_{current} \times B_{logo} \times \frac{G_{bg}}{G_{logo}} \quad (1)$$

Where $I_{current}$ indicates the luminance of current region, B_{logo} indicates the binary of logo mask, G_{bg} indicates average gray of background, G_{logo} indicates average gray of logo.

There is another restrain method that is to scale the RGB channels of the logo to the current regions background respectively which makes the logo more similar to the background as show in figure 5c. The restrain methods can be selected according to personal preferences.

3.4 Channels Switch Mechanism

In view of the special situation on TV channels changing [6], there is the principle that V channel in logo region will change dramatically after channels changing. Channels change mechanism need to store the logo mask of the current channel, calculates the difference between the current frame and the logo mask in real time, and when the average difference by pixels is greater than a given threshold, that implies the current display channel has changed and whole mechanism will be re-triggered. This method considers the practical situation of changing the channels which lead to different logo mask. The formula of channels change mechanism is expressed as equation (2).

$$\Delta V_{mean} = mean(V_{current}(x,y) - V_{logo}(x,y)), \quad (\forall x, y \in logo) \quad (2)$$

Where $V_{current}$ indicates the logo luminance of current frame, V_{logo} indicates the luminance of logo mask, ΔV_{mean} indicates average difference between the current frame and the logo mask.

3.5 Inertial Mechanism

Based on the consideration of stability, an inertial mechanism is integrated to detect signal flicker in video streams. When average difference between the current frame and the logo mask is so great to trigger mechanism, calculate the difference again after one second. If the difference is still great, the mechanism will be triggered immediately; otherwise, the algorithm will do nothing and maintain the original state. Thus, the problem of false trigger caused by signal flicker can be solved.

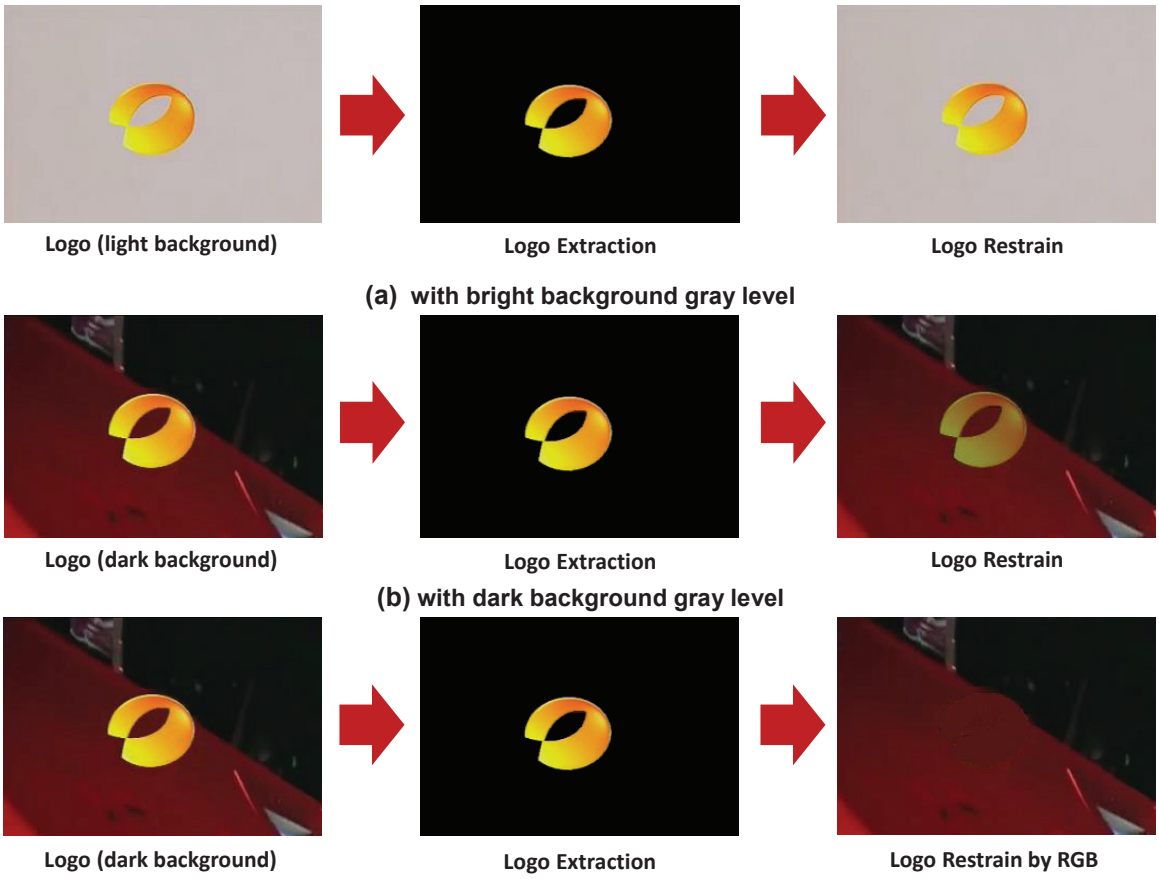


Fig. 5 Logo restrain performance with different background gray level.

4. RESULTS

4.1 Experimental Results

Our experimental video data (around 4 hours) is extensively collected from translucent logos, such as CCTV1, and opaque logos, such as HNTV. The video is in MPEG-4 format with the frame rate of 30 fps and resolution of 1080p. The average luminance reduction of the logo region were measured in the video. The proposed algorithm is implemented in software and the luminance is measured through the measuring equipment in actual OLED panel. The proposed algorithm can reduce the image sticking of opaque logos by about 30% and by about 23% for translucent logos compared with without any image sticking algorithm. The life time is increased about 25%.

4.2 Partition Detection

Previous Logo detection methods require a large amount of computational resource and memory to apply these methods. The amount of memory space required to store one frame of FHD image is about 50Mbit. In this paper, the proposed algorithm adopts interlaced row and column interval scanning mechanism. It is able to detect the logo correctly and to control the brightness according to the background by using only 10% of original memory resource, when it applied to the FPGA H/W system. By means of pre-defined region search, the hardware resource requirement can be simplified dramatically and also fulfill good accurate extraction and restrain performance.

5. SUMMARY

In this paper, we have proposed a way to extend the lifetime of OLED TV by suppress persistent TV logos. This method can detect the logo accurately with less resource. The image sticking phenomenon of OLED TV can be reduced by minimizing the luminance of the background in real time to relieve the OLED material degradation. The proposed algorithm is also easy to implement in hardware.

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