Image Analysis-Based Perceptual Quality-Retaining Power Saving for OLED Display

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Abstract
This paper proposes an image analysis-based OLED display power-saving framework to reduce the power consumption of OLED displays while retaining perceptual quality. Specifically, the framework selectively adjusts Saturation and Value in HSV color space based on the human visual perception masks for color change and brightness change. Further, to retain the quality of the image, a sub-color component selection scheme is also proposed. The qualitative and quantitative evaluation proved the advantages and practicability of the proposed framework in reducing power consumption while retaining perceptual image quality.

Keywords
OLED display, power saving, HSV color space, perceptual quality-retaining, image analysis

1. Introduction

OLED displays have been increasingly introduced in various industries, including automotive, mobile devices, and consumer electronics, due to their advantages of excellent contrast, low power consumption, and lighter layers [1]. The power consumption of OLED displays is directly related to the contents displayed on the displays [2], and the power consumption of each OLED affects the lifetime of the OLED displays [3]. Thus, power saving is essential for the success of OLED displays, especially in automotive applications where electronic cars have been increasingly introduced to the markets. Automotive vehicles have increasingly adopted displays more and more, which require more power consumption [4]. Thus, reducing power consumption is an essential requirement, especially for electric vehicles.

This paper proposes a novel framework to reduce the power consumption of OLED displays while retaining perceptual image quality based on image analysis and human visual perception of color and brightness changes. The main contributions of this paper are summarized as follows.

- The proposed framework reduces power consumption while retaining the perceptual image quality of OLED displays based on image and environmental analysis and human change perception masks.

- The proposed framework further retains the perceptual image quality of OLED displays by adopting a sub-color component selective process.

- Qualitative and quantitative experimental results show the effectiveness and practicability of the proposed framework.

The remaining of this paper is organized as follows. Section 2 describes the proposed perceptual quality-retaining power-saving framework for OLED displays in detail. Experimental results are given in Section 3. Lastly, Section 4 concludes this paper with some future works.

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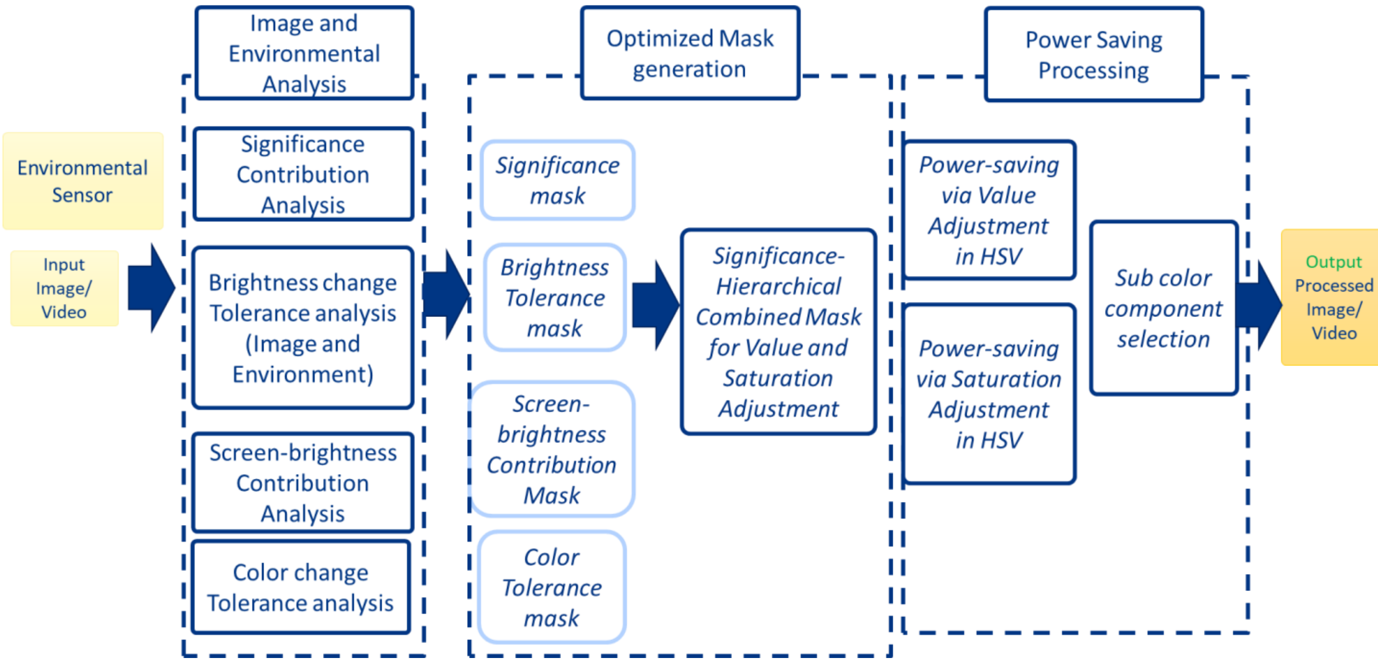

Figure 1. The diagram of the proposed framework

2. The proposed framework

As shown in Fig. 1, the proposed framework consists of the image and environmental analysis module, optimized mask generation module, and power-saving processing module. The image and environmental analysis module analyzes the input image and environmental sensor signals to construct four masks, including significance mask, M_s, screen-brightness contribution mask, M_b, brightness tolerance mask, M_{bt}, and color tolerance mask, M_{ct}. The significance mask, M_s, is generated based on saliency information, object information, road information, and region of interest. The screen-brightness contribution mask, M_b, is generated based on the ratio among R, G, B color channel values, which has higher values when G/R and G/B are greater. The brightness tolerance mask, M_{bt}, and the color tolerance mask, M_{ct}, represent how the brightness change and the color change are perceptually perceived by humans, respectively.

The optimized mask generation module constructs the bright adjustment mask, M_{ba}, and the saturation adjustment mask, M_{sa}, based on the four masks M_s, M_b, M_{bt}, and M_{ct}, generated in image and environmental analysis module. The significance levels for each pixel is determined based on the significance mask, M_s. Examples of significance levels can be L0: critical region, L1: significant region, L2: less significant region, and L3: no significant region. Brightness adjustment mask, M_{ba}, is obtained via optimizing significance level and brightness tolerance mask M_{bt}. Saturation adjustment mask, M_{sa}, is obtained via optimizing significance level, screen-brightness contribution mask $\mathbf{M_b}$, and color tolerance mask M_{ct}.

The power-saving process module processes an input image based on two adjustment masks, M_{ba} and M_{sa}. First, the input image is color-space converted from RGB into HSV color space. Then, the value of V (value) in HSV color space is adjusted based on the brightness adjustment mask and power-saving parameter **p**. Also, the value of S (saturation) in HSV color space is adjusted based on the saturation adjustment mask and power-saving parameter **p**. The obtained value-adjusted V-channel image and the saturation-adjusted S-channel image are combined with the original H-channel image and then converted to RGB color space. In order to further retain the perceptual image quality of the processed image, this paper introduces the sub-color

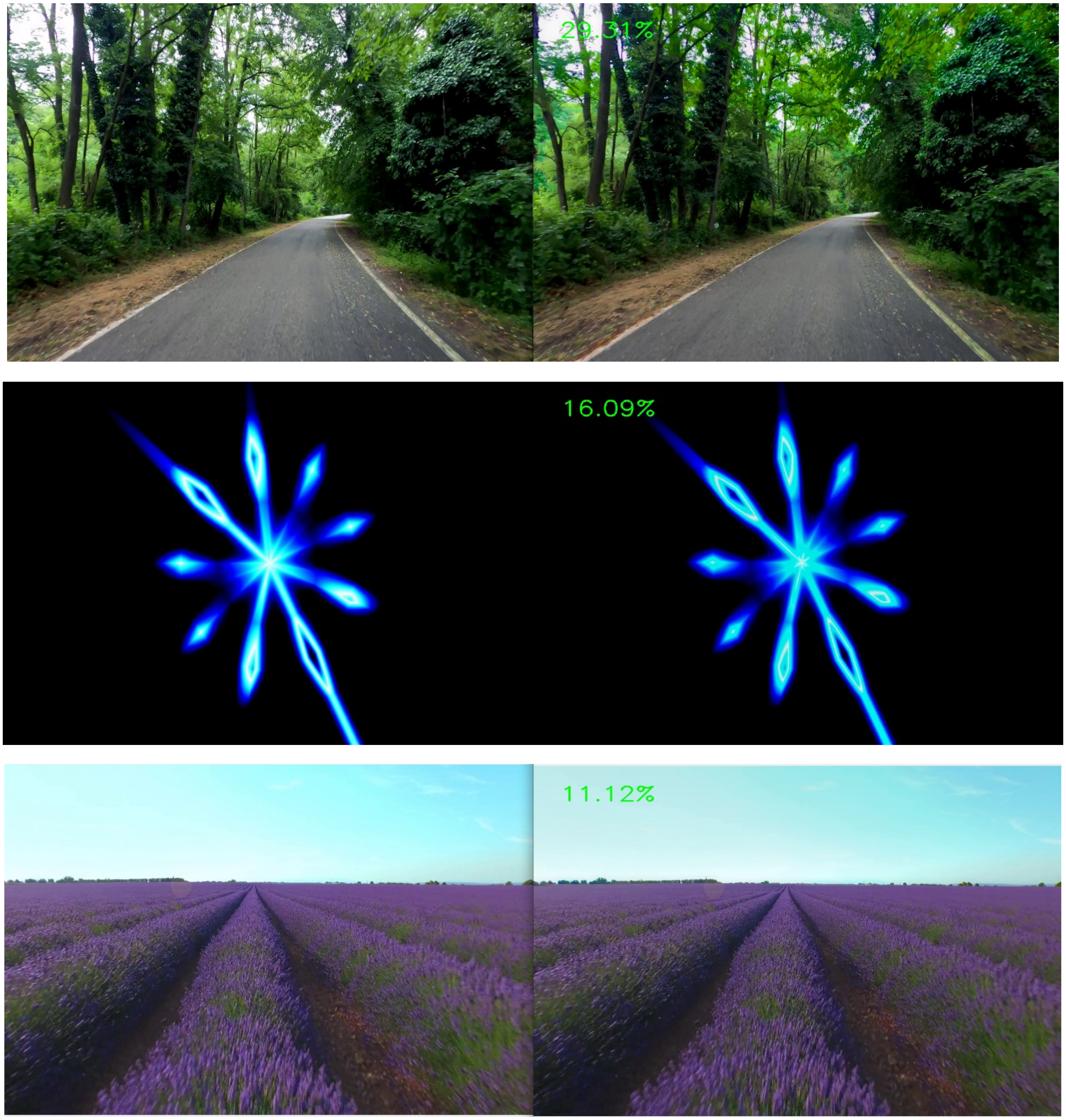

Figure *2*. Examples of the processed images by the proposed framework. The left image represents the original image and the right image represents the power-saved image. The number given in the right image indicates the amount of power saving.

component selective processing, which selects one or two color components (R/G/B) from the processed image and selects the remaining components from the original image.

3. Experimental Results

In order to evaluate the proposed framework, we conducted a qualitative evaluation and quantitative evaluation on the Irystec video dataset. The dataset includes 40 videos in various resolutions. Fig. 2 shows examples of the processed image, where the left image represents the original image and the right image represents the power-saved image. The number given in the right image indicates the amount of power saving. The proposed frameworks gain 20% of power savings on average. The qualitative evaluation shows that the perceptual quality degradation is perceptually acceptable (92% of quality score).

4. Conclusion

This paper proposes proposed perceptual quality-retaining power-saving framework for OLED displays, which consists of the image analysis, optimized mask generation, and power saving processing modules. Experimental results show that the proposed method is promising in reducing power consumption of images on OLED displays. Future works will include increasing the robustness and generalization ability of the proposed framework via machine learning framework.

5. References

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