Advances in Computational Sciences and Technology
ISSN 0973-6107 Volume 10, Number 7 (2017) pp. 2183-2190

http://www.ripublication.com

# Role of Color Processing in Display

**Mani Kunnathettu Rajee**
*PG Student, Vellore Institute of Technology, Vellore, India.*

**Bagubali A**
*Assistant Professor ,SENSE ,VIT University,* Vellore, India.

**Abstract**

Displays forms the most important component of any system as major share of the user interaction to the system is guided by the graphical user interfaces. The human eyes are the best sensors for the natural colors and can distinguish lot more colors than the best camera today can capture, the display technology is still far behind and is trying to catch up, and color processing is adopted to cover up the gap of capabilities. Though this was the primary objective of color processing, in modern devices the scope of color processing has grown beyond this limit. It has empowered to implement user friendly visual experience with a much efficient time and power profiles. With the introduction of new materials and technologies into the display domain the processing stages advanced and this has led to higher possibilities for enhancement of the user experience. This paper discuss the color processing in its native approach and then the further sections explores the additional areas where color processing helps the display system like tone mapping, power saving support and so on.

## I. INTRODUCTION

The visual experience provided to the user depends largely on the reproduction of accurate colors on the display unit. Whether it be on a mobile platform with a smaller screen or be it a Display device spreading across a room, each require the appropriate processing of the color data to give the viewer the feel of true color. Color can convey feelings much more than what we actually see. The slight variation in the perceived color can result in a really bad user experience especially when the display is used for the displaying natural colors.

The human eye can identify a wide variety of colors, but the current display technology have limitations that only a part of the colors identified by the eye can be reproduced on the display. The capability of the capturing devices are higher than the display devices thus displays are undergoing development to catch up. With advancement of technology the reproducible natural colors have risen. To make up the differences in the color perceiving and reproduction abilities it is necessary to have color processing on the image data before it is displayed so that the user can have an acceptable experience with the reproduced image. This is the primary objective of color processing, this paper discuss on the need for color processing and then goes into inspecting the other uses of color processing which helps in the modern display to be efficient devices in term of display quality and power.

## II. COLOR PROCESSING IN DISPLAY

Basic color processing involves gamma correction and color space conversion. These can be supplemented with other operations such as brightness correction, alpha blending etc. These for the standard usage set for color processing in the conventional definitions.

The Gamma correction ensures that the darker regions of the image are enhanced for better view ability , this is necessary as the human eyes are more sensitive to slight changes in the darker regions that the similar changes in the brighter side.

The color space conversion comes into picture due to the variable color space support of the devices. In the most general scenario the capturing device captures the image and provides the data in the device specific model. This image data needs to be converted to a standard format for storage and transmission. Also a similar scenario can occur at the display device end. The image data that is stored may not be the matching device dependent model that the device can reproduce. Thus the RGB content in the stored data needs to be converted to the device supported format with proper mapping so that the reproduced image is visually correct for the user.

Color processing also includes adjustment of the display characteristics so that the user gets a pleasurable viewing experience. This includes brightness correction, contrast enhancement and other color correction methods. These are adopted on images that are poorly captured but are processed to get a better viewing experience. In case of multi-window and multiplane display environment, blending also becomes an important operation. Blending ensures that multiple layers are composed together based on the transparency of layers and their order of appearance. The pixels has to be carefully processed so that the blended colors are accurately produced and the composed image is properly rendered for the display panel reproducible color space.

These formed the conventional use of color processing in the display technology and are the core essentiality of the processing. But in modern display systems color processing can aid in many more dimensions that enhances the user experience with displays. The next section describes the role of color processing that enables multiple display standards. And the later sections describes the usage of color in other domain including power savings and device dependent technologies.

## III. DEVICE SUPPORT

One important requirement for color processing is to enable the display support over the wide variety of displays available .Thus it has become possible for the same image data to be used for any of the displays. This is important because there exists different color spaces and these vary from manufacturer to manufacturer. For example the image content may be captured with AdobeRGB color space but the display may have an SRGB color space, thus the colors need to be mapped appropriately so that the reproduction in the display does not cause any visual glitch. Another case is that a single device may have multiple displays attached to it, in such a situation the same image data needs to be processed in different way for each of the display. One may be a high color HDMI display whereas the other may be a standard embedded display, the same content displayed on each of it has to be adjusted to match its supported color space to ensure that there is no loss of color data in reproduction.

## IV. OLED COLOR TRANSFORMATION

Display screen is the most power consuming component in a mobile system. Today we see that most of the systems use LCD or OLED displays as the primary display surface. OLED do not require the backlight thus can be more power efficient than the LCD device, especially when the content to be displayed are dark. This is mainly attributed to the self-emissive nature of the OLED. Many researchers have worked on profiling the power characteristics of OLEDs so that they can be implemented as a power efficient display option.

One major challenge faced by OLED is that when displaying bright colors, the OLED may use more power. It has been identified that there are certain colors which can be classified as power hungry colors. For example it is seen that blue diodes consume around 15% more power than red diodes at higher intensities. This problem can be overcome by use of the energy-friendly colors on the display thus make the OLED power friendly. A method to perform this is to use a color conversion system that can map the power hungry colors to a power friendly color representation in such a way that the visual quality of the image is not effected [4]. That is it should reduce power consumption without causing any change to the user experience, this become possible exploiting the human color discrimination limitations.

In this model, a color map table is generated by an optimizer .In run time the input colors are mapped to the energy efficient colors in the rendering stage. Thus the screen receives a modified image buffer which has energy friendly pixel values thus prevents the power drain. The user experience is maintained as the human eye cannot detect every change due to the color perception impreciseness. Thus with help of proper mapping of the colors in a power efficient color space we can use the OLEDs to be a power efficient display.

## V. DARK IMAGE ENHANCEMENT

Dark images are always a challenge for human vision as well as for machine vision. These images may be a result of unbalanced illumination or could be due to poor capture capability of the device that captured the image. Contrast enhancement is one the major solution to the problem. In situation described above the enhancement should be done in such a way that it does not result in loss of the intrinsic features of the image. The enhancement is performed based on the histogram data of the pixels and often finds this very useful in case of images like satellite images or dark scene night images.

Gamma correction is an option to enhance dark images, but global gamma may cause unintended changes to the image causing visual impact on the image features [5], thus the correction must be applied in an intelligent manner. The enhancement proposed can be easily implemented on greyscale image. In case of color image HSV model is preferred. This is because in this model the chromatic component and the non-chromatic component can easily be analyzed separately. The control mechanism is implemented by adjusting the luminance component only and preserves the hue and saturation levels. The human eyes perceive change in color more than the change in brightness so the change of luminance can be easily be used for image enhancement.

## VI. ADAPTIVE ILLUMINATION

The major portion of power consumed by an LCD display goes to the backlight. The LCD works with the principle of backlight illumination and polarization of the middle layers. Thus any kind of savings in the backlight power leads to power saving in the LCD display. One method to have savings in the backlight by the use of color processing to establish adaptive illumination [6][1].The colors can be processed to attain better local detail enhancement. Mathematical estimations can be done on the input image so that the transformation can be done without causing any visual disruption for the user. The concept of perceived brightness can be used based on the content so that even though the changes are in place the human eye remain insensitive to such changes[3].

For streamed video contents a feasible approach that is being used is to use a cloud based computing methods to calculate the impact of the color data on the display and perform cloud processing [9].These proves good in computational power saving but it brings in an additional cost of communication between the device and the cloud. This become prominent when the content to be played is more local storage than a stream content. Thus invokes the need for offline methods. Visual content based Backlight adjustment [8] is another method which can solve the problems proposed above. Along with that there are two major points that effect the visual experience that needs handling. One being the effect of human visual perception on frame motion. Second, most of the algorithms concentrate on the objective video quality assessment but ignore the visual perception of eyes. Thus to consider these points into the adaptive illumination, we need to use a non-linear pixel compensation while performing backlight savings. Thus invokes color processing into the illumination system. The traditional backlight dimming algorithms concentrated on linear enhancement, but this causes deterioration of the user experience when the overall image is bright and it results in clipping of the light areas .The non-linear enhancement ensures that the enhanced image is perceived same as the original by the human eyes.

## VII. DYNAMIC TONE MAPPING

It has been observed that display contents of similar nature shows similar power characteristics. This is more prominent when we consider the cases of playing videos. In case of mobile devices video playbacks can be attributed as a major consumer of the power. Thus its worth to analyze the feasibility of improving the power performance in this regard. On analysis, it has been seen that video streams that can be categorized share common power features such as color motion energy, power color distribution etc. One feasible measure to face this is to implement a dynamic tone mapping based on the content classification[2]

The system in this case uses a hidden markov model classifier to classify the video content based on its effect on the OLED screen characteristics. Based on the classification a dynamic tone mapping is performed on the content such that the output is remapped to non-power hungry region of color in such a way that the power output is conversed and visual quality is maintained. The concept of video classification is based on the fact that similar types have similar characteristics, for example a movie trailers have peak color distribution and higher scene transition rates where as a news clip will have better distributions and les of scene transitions but more dynamic windows. In case of cartoon and animation types the majority of content will be based on synthetic color contents rather than natural colors thus have a different category of profile.

Dynamic Tone mapping is a concept that was introduced to recode the display colors by mapping functions. It can refine brightness explosion and dimming effects in HDR processing. At the same time this can be modified to be a power saving technology in case of OLED displays. The video stream are power profiled based on its content. The profiling includes detecting key frames, power profiling ,scene detection etc. The tone mapping is then performed. It includes color remapping, hue tuning and saturation tuning. As discussed in the section IV, the color mapping is aimed at replacing the power hungry components in the image with power friendly color components. This is specific to the OLEDs as the power consumption profile for the different color LEDs are not uniform over the brightness curve.

Saturation tuning is performed over the data so that the overall luminance of the display is not effected by the mapping process. Human eyes are very much sensitive to the luminance changes than the chroma changes. When we consider the HSV system it can be seen that the V value can represent the luminance, thus when mapping is performed we ensure that the effective luminance is preserved when the chroma remapping to power efficient colors are performed. Hue tuning can be used to minimize the display power when the display is dominated by hungry colors with high dynamic variations

## VIII. SATURATION CONTROL

One of the important issues faced in OLED display is the power dissipation on displaying high brightness images. On adopting a signal level power reduction it is often seen that it results in the image getting desaturated, this is mainly accounted due to a constant ratio desaturation factor used for scaling. A novel approach to this is to use adaptive color saturation control to control the power loss in OLED[7]. This is based on analyzing the image and exploiting the perceptual color redundancy that exits in natural images.

In RGBW uses a white emitter along with color fillers. The design is such a way that the W subpixels are the most energy efficient thus the aim is to enhance the image color in such a way that the same visual impact can be created by the use of more effect from the W sub pixel component and reduce the contribution by the RGB subpixels whenever possible .This envisages a large scale power saving especially in large Display panels that can have considerable power consumption.

In this method the correction is done in such a way that the luminance component of the image is not affected. Any change on luminance is highly noticed by the user, this is because the human eyes are more sensitive to the luminance change. Also change in luminance can lead to change in the image contrast requirement for easy view ability. Thus in this method the Colorimetric accuracy is maintained. The luminance reduction form the RGB component is compensated by the W component. Thus the color processing aims at analyzing the image and adaptively control the RGBW subcomponents to optimize the power consumption for the device to attain the same visual quality experience.

## IX. CONCLUSION

Color processing has been part of display pipe. The conventional idea was to process the color to support the display standard, but modern day color processing play more than the conventional role. It can bring up image captured poor quality .It can enhance dark images for better view ability. The color processing is used to enhance the visual experience and at the same time provide an energy efficient display solutions. This is more important in case of mobile devices that aims at maximum power saving to get the best battery performance. Thus color processing performs visual enhancement along with power saving dynamically with respect to the display device attached to give the best performance.

## REFERENCES

[1] Soo-Chnag Pei and Chih-Tsung Shen, Color Enhancement with Adaptive Illumination Estimation for Low-Backlighted Displays, IEEE Transactions on Multimedia, 1520-9210,2016

[2] Xiang Chen, Yiran Chen,Chun Jason Xue, DaTuM:Dynamic Tone Mapping Technique for OLED Display Power saving Based on Video Classification

[3] Minyoung Park, Minseok Song, Saving Power in Video Playback on OLED Displays by Acceptable Changes to Perceived Brightness , Journal of Display Technology, Vol 12,No.5, May 2016

[4] Seikwon Kim,Shinyoeong Hyun ,Taekyunh Heo ,Daegil Im , Blind:Power Saving Color Transform Method for OLED Displays, 2016 IEEE International Conference on Consumer Electronics (ICCE)

[5] H.Singh ,N.Agarwal,A.Kumar,G.K.Singh, A Novel Gamma Correction Approach Using Optimally Clipped Sub-equalisation for Dark Imgae Enhancement, IEEE Transactions

[6] Kyle Shih-Huang Lo,Jia-Ying Lin, A High-Efficiency Dynamic Backlight Dimming Algorithm Based on Visual Content Analysis , 2016 IEEE 5th Global Conference on Consumer Electronics

[7] Ji-Hoon Choi,Myongyoung Lee ,Jong-Ok Kim, Adaptive Color Saturation Control for Low Power RGBW OLED Displays ,Journal of Display Technology , Vol.12 ,No.8 ,August 2016

[8] Kyle Shih-Huang,Jia-Ying Lin,Chia-Hung, A High-Efficiency Dynamic

Backlight Dimming Algorithm Based on Visual Content Analsis,2016 IEEE 5th Global Conference on Consumer Electronics

[9] C.-H Lin,P.-C Hsiu ,Dynamic backlight scaling optimization;a cloud based energy saving service for mobile streaming applications, IEEE transactions on computers,vol.63 no.2, February 2014