Use of the Chromation Spectrometer for White Point Balancing in Mobile Devices

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Abstract
White point matching in mobile devices re-sets the colorimetric white point for a system to match the white point seen from an ambient illuminator, allowing for matched performance between the white on a screen and ambient environmental white references. This feature improves perceived spectral quality and overall display performance. With its broad spectral responsivity, high wavelength resolution, and compact size Chromation's device serves this application and, in a single device, can offer several functions including ambient light measurement and analysis, white point matching, and proximity detection. Use of a spectrometer such as Chromation's also unlocks several other features and applications systems of interest to consumers such as use of the sensor for absolute color measurement, for white balancing photographs, and full spectral pulse oximetry.

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Introduction to white point matching

It has been known for some time that user color perception is affected by the local adaptation to the white point in the environment.[1] This effect appears to be related to perceptual changes that also deliver color constancy, which allows for the perception of relatively unchanging colors and whites in objects in the presence of varying light sources.[2] A consequence of this adaptation is that colors appear incorrect in display products if the ambient white point does not match the display's white point due to maladaptation of the viewer.

Apple True Tone

To better match the perceived colors in display products several high end Apple devices with DCI-P3 color gamut displays incorporate an adaptive color adjustment which requires a spectral sensor that accurately detects the white point. The products that incorporate this technology include all of Apple's 2017 launched mobile products including the iPad Pro (both sizes), iPhone 8, iPhone 8+, and the iPhone X. This technology is branded as "True Tone" and is expected to be included in additional Apple products incorporating the DCI-P3 expanded gamut including Macintosh computers.

Zhang (Jerry) Jia was one of the co-inventors of the Chromation technology while he was a student at Columbia. Jerry was hired by Apple after graduating for his optics expertise and is co-inventor in a number of patent applications relating to TrueTone technology, its sensors, and the calibration of the measurement devices.

Current color sensor products on the market

There are several color sensors in the market that are suitable for white point identification. Austria Microsystems (AMS) acquired MAZeT GmbH in 2016, which produces several 4 and 8-channel color sensors in their Jenacolor line used for lighting adjustment and medical applications. Around the same time as the MAZeT acquisition, AMS announced the AS7261 four channel sensor product, which is believed to be related to the device used for Apple's TrueTone sensor. The AS7261 system measures four channels - it has three CIE-matched interference filters and a fourth channel for IR sensing. The IR channel allows the sensor to also operate as a proximity sensor for use in cell phone screen blanking; the device replaces three components; the ambient light sensor, a white point matching sensor, and the proximity sensor on a cell phone.

A second area for spectral sensing opportunity in mobile devices is setting an absolute white point for photographic images. The LG G4 phone released in 2015 has an AMS TCS3400 four channel spectral sensor on the back side of the phone, which is used in conjunction with the photographic camera of the phone. The phone saves an absolute and accurate white point measurement together with its camera images. [3] A second possible use of the spectral sensor is to adjust the colors of the flash used in multi-color LED flash systems to selectively compensate for wavelengths of light that are missing in the ambient light. This type of dynamic flash, which is used in all modern mobile phone camera systems, allows for better use of the phone's dynamic range and white balancing, significantly improving the photographs taken.

Figure 1. Example of white point modification to match the ambient white point.[4] Viewers accommodate to the white point in the environment, and colors in a display appear incorrect when seen after adaptation to a white point different from the display's reference. Adjustment of the color space to the ambient white point matches this accommodation, yielding a perceptual match of the images shown on the display independent of the environment.

Delivering additional functionality in mobile devices

In addition to serving as a front-side proximity sensor, ambient light measurement system, and white point identification system, a full spectral sensor on a mobile device can be used for a number of additional mobile device functionalities, in most cases without the need to add additional hardware.

Dynamic flash and photographic white point A spectral sensor allows for the identification of the white point for main camera photographs. In cameras equipped with multi-color LED flash (which includes most modern smartphones), the spectral analysis can further be used to identify the wavelengths of flash that can fill in the deficient wavelengths in the scene and provide a more balanced white point and a superior SNR for the camera image.

Color measurement A spectral sensor combined with a wide spectrum illuminator can be used for absolute color measurement, in which the difference in spectrum from the illuminator can be used to subtract the influence of the ambient light in the environment. This functionality can be used for surface color matching, e.g. matching wallpaper or paint to samples or furniture, analyzing skin tone or make-up, and for a variety of authentication and document analysis applications.

Ambient light analysis Several ambient light measurements are of interest to consumers, and the measurement of the ambient light spectrum can be used to analyze the environment without an investment in additional hardware. The measurement of photosynthetic active radiation is of interest to plant growers. The measurement of UV light intensity can be used for an analysis of sunburn risk, the determination of the longevity and effectiveness of sunscreen, and to provide evidence-based reminders to reapply sunscreen or seek shade. The analysis of light for its short wavelength content can be used to assess the degree to which exposure has an effect on circadian entrainment.

Pulse oximetry Together with a white illuminator (which can be the same unit as the flash), a spectral sensor can be used as a fingertip pulse oximeter and to determine heart rate, oxygenation, and the quality of perfusion.

Size of the market opportunity

Mobile telephones represent a 1.5 billion unit per year opportunity, and incorporation in a single model from any leading manufacturer represents a significant potential volume; at least two spectrometers can be used effectively (one on the front and one on the back) in each mobile phone. In addition to integration for white point analysis, a move to the Chromation device unlocks a range of new potential features while maintaining many of the functionalities that are provided by independent devices or four channel sensors today. Several parallel consumer market areas, such as integration into smart watches (13M units/year) and computers (240M units/year) can also take advantage of this technology.

Chromation is in discussion with representatives from Samsung, Huawei, and Apple (both the display and optical sensors group), and has hosted two visits (Samsung and Apple) to our offices. The market information and these interactions have confirmed that this application represents a significant opportunity for sales and a potential exit through acquisition by a partner.

References

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