The MultiSync ® PA Series of Professional Display Offers Both Accurate Color Reproduction and High Usability

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Abstract

Digital imaging has been the driver of the utilization of color management in order to match color tones across different I/O devices. Conventional displays need complicated adjustments (calibration) using an externally attached color sensor to effectively reproduce color correctly, but the new MultiSync ® PA Series displays offer both accurate color reproduction and calibration-free operation for many types of users. This advance is due to the combination of a newly developed image processor ASIC and correction algorithms.

Keywords

color management, calibration, ICC profile, color emulation, color universal design

1. Introduction

The digital imaging industry promotes "color management" for reproducing the same color tones across various input/output devices such as digital cameras, scanners, printers and displays. Principally for small and medium businesses that produce content for imaging professionals including photographers (hereinafter referred to as the content producers), color management provides the following advantages. 1) produced content can be viewed using the user's environment, and; 2) early reviews of the work by customers can quickly correct issues early in the workflow. Since the content producers are located upstream of the digital workflow (**Fig. 1**), the utilization of color management increases the overall efficiency of the workflow.

With the newly developed MultiSync ® PA Series, NEC adopted several considerations so that many users can easily utilize color management. As a part of the development of the MultiSync ® PA Series, we placed particular emphasis on ease of use in displaying more accurate colors more easily with the display, along with the ability to very accurately simulate standard color management without using a color sensor.

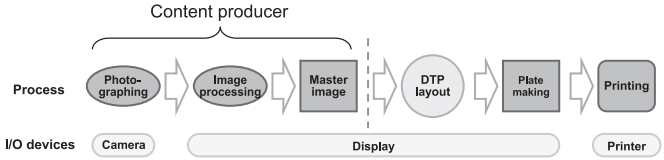

Fig. 1 Example of image content product workflow.

2. Issues in Color Management

Color management of displays typically requires measurement of predetermined colors by a color sensor and adjustment of the measurement results using targeted color values (calibration). Although this work is essential for displaying correct colors, it necessitates skill and knowledge as well as effort including preparation of the color sensor and setup of the display. We have been able to determine that the main issue preventing wide usage of color management is the lack of inherent display accuracy and the difficulty of calibration for new users.

(1) Precision improvement issue

With regard to calibration, the display characteristics (white points, color gamut, gamma, etc.) are measured and an ICC profile [1] is compiled at the same time as the display adjustment. The software viewer corrects the images based on the ICC profile, ideally producing a correct color match. Sometimes, however, the actual color tones obtained after correction do not always match the original colors due to color measuring errors caused by individual characteristics and tolerances of the color sensor. As a result, many users attempt additional manual adjustment of the display, but this procedure is far from being ideal for effective color management.

(2) Usability improvement issue

The multi-step, manual calibration described above is burden to users. In addition, many software applications still assume that every display device conforms only to the sRGB [2] standard, which is one of more common standard color specifications. When an image is displayed expecting an sRGB display on a display with a larger color gamut, the colors can appear oversaturated. Because much of this software does not consider the ICC profile settings, dedicated image viewing software is often required for viewing accurate color.

(3) Diversification of the display requirements

The primary motive behind the industry's promotion of color management was the need to improve workflow efficiency by reducing the rework generated by manual print matching. In practice, this consists of adjusting of each output device such as the printer and the display unit based on the actual characteristics that appear when the image is printed. In addition, the diversity of the users viewing the contents (including those with color vision deficiencies) has become more prominent. This has increased the demand for production of color materials including printed matter and web pages that are compatible with Color Universal Design (CUD) in order to ensure high visual acuity for those people with various color vision characteristics [3] . Color management of the future will be required to improve the efficiency of the processes to meet the wide variety of display requirements including CUD.

3. The New Approach of the MultiSync ® PA Series

In order to improve the display accuracy and usability and to respond to display diversification requirements, the MultiSync ® PA Series has introduced the following new concepts based on the previous calibration-compatible displays (the MultiSync ® 90 Series). These concepts are innovative and several patents are pending.

3.1 Improvement of Display Color Accuracy

The correction values required for the video circuitry of the display vary depending on various target values such as the luminance, white points and color gamut as well as the environmental conditions, including the room temperature, screen rotation and long-term usage. Therefore, for current displays that have fixed correction values, it is essential to perform calibration according to each environment of use (**Fig. 2** , Left).

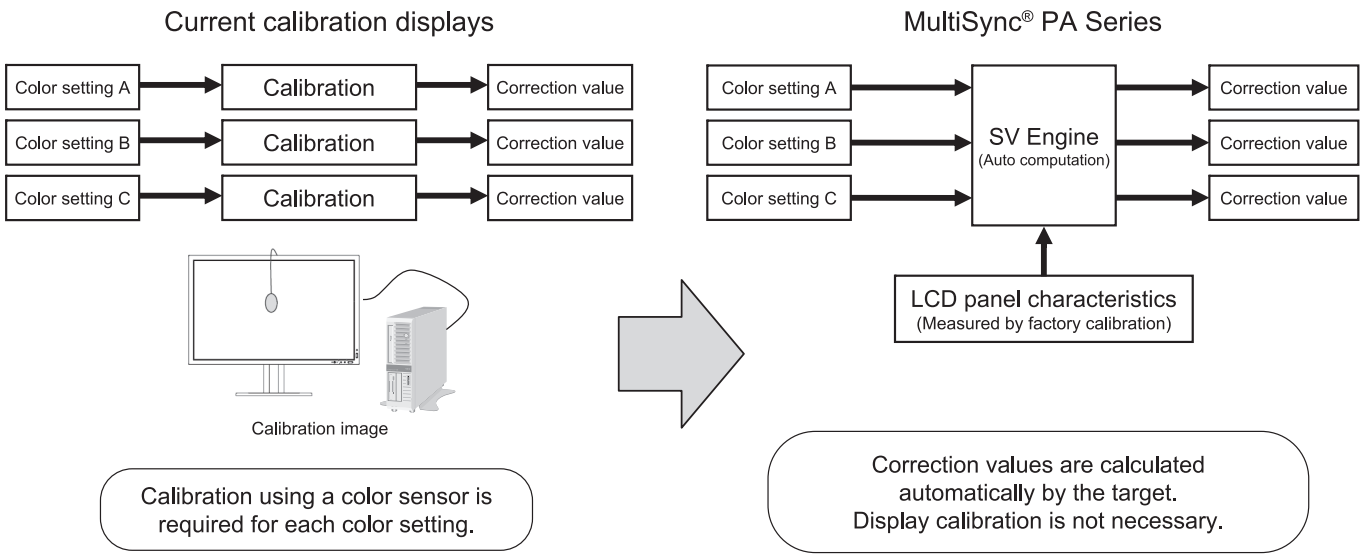

Fig. 2 Differences in correction value generation methods.

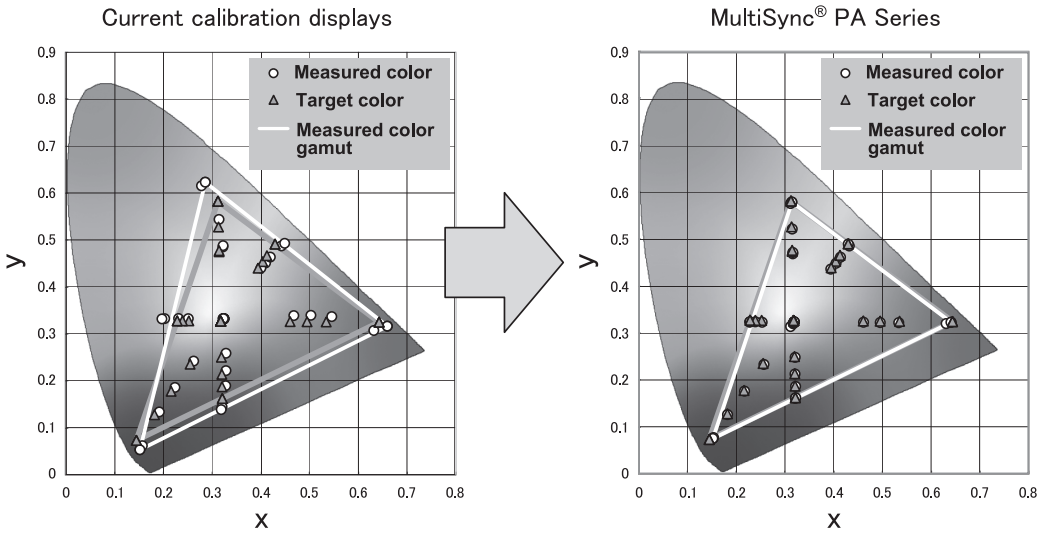

Fig. 3 Comparison of color difference in xy chromaticity diagrams.

With the MultiSync ® PA Series, we solved this issue by developing the SpectraView ® engine that fuses an image processor ASIC (Application Specific Integrated Circuit) and correction algorithms to generate correction values by tracking variations in target values and environmental conditions in real time. This solution also corrects the shift of color/luminance after long use so that the previously necessary calibration can now be omitted (Fig. 2, Right).

(1) Accuracy improvements

Generic displays perform linear correction of the RGB video signals so that the corrections to primary colors are interlocked with other colors. However, in general, independent corrections are required for the primary colors, secondary colors and white points. This is because of the nonlinear relationship between the RGB signals and human vision characteristics (the tristimulus values known as XYZ). To accomplish nonlinear correction, the SpectraView ® engine incorporates a 3D color look up table (LUT) in the image processor ASIC. It has more than 700 correction points in the color gamut and features a high degree of freedom capable of independent correction of the display colors of each correction point.

Highly precise control of the correction points is accomplished via the correction algorithms that calculate ideal colors using the XYZ values based on the nonlinear relationship between the RGB signals and the XYZ values. The optical data of the LCD panel (e.g. luminance, white points, color gamut and gamma characteristics) used in the computations are measured by each set with high-precision instrumentation at the NEC factory. In addition, various characteristics including the screen uniformity (mura) and ambient light sensor are measured at the factory and this data is also utilized in the display correction.

The synergy of the image processor and algorithms described above allows the MultiSync ® PA Series to decrease the color difference between the target and measured colors compared to the current calibration displays, to a level approaching that of the limits of human visibility (average ΔE94 less than 1.0) (**Fig. 3**).

(2) Stabilization of the display color

In order to maintain the factory calibration performance in the user environments, it is necessary to reduce color shifting due to the operating environment or to long periods of operation.

An example of color shifting due to the operating environment is the shifting in xy chromaticity of a white point due to an elevated room temperature or display luminance. The SpectraView ® engine continuously calculates the current chromaticity using the built-in backlight and temperature sensors, then stabilize white points automatically, during user operation. This correction makes it possible to reduce the color shifting Δ|xy| less than 5/1000, which means

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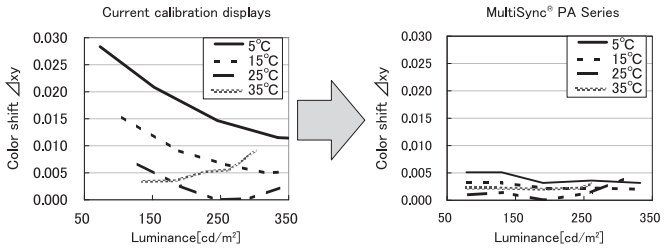

Fig. 4 Color shifting of white points influenced by room temperature and display luminance (compared to 25 degrees, 250cd/m²).

less than 1/6 of the current displays (**Fig. 4**).

Color shifting due to years of usage can also occur in some external color sensors for calibration as well as in the display. With low-end color sensors, the time degradation of color filters due to absorption of moisture, etc. is very noticeable. And there are known cases in which color shifting of Δ|xy| larger than 100/1000 was produced after a few years even when calibration was continued over this period. To solve this issue, we incorporated the new self-color correction function in the MultiSync ® PA Series that internally detects and corrects the yellowish color shifting with long term usage of the display. It calculates the color shifting based on the luminance efficiency detected using a built-in backlight sensor (that does not have color filters) and the data accumulated from the years of long-term test. As a result, our evaluation sample that was used for two years in a normal office environment presented color shifting of Δ|xy| nearly equal 5/1000, which means higher display stability than that obtained by calibrations using low end external sensors that incorporated color filters.

3.2 Improved Usability

The MultiSync ® PA Series not only reduces the amount of work by eliminating calibration, but also improves usability with the help of the following functions.

(1) Color emulations

To enable the reproduction of the color tones of other display devices, we incorporated a color management engine based on the ICC profile in the display (**Fig. 5**).

1) The ICC profile emulation function reproduces the color tones of industry standards such as sRGB as well as of other displays. 2) The print emulation function reproduces the color tones of paper, ink, etc. of each printer. 3) The color vision emulation function confirms the decrease in legibility depending on the color vision characteristics of

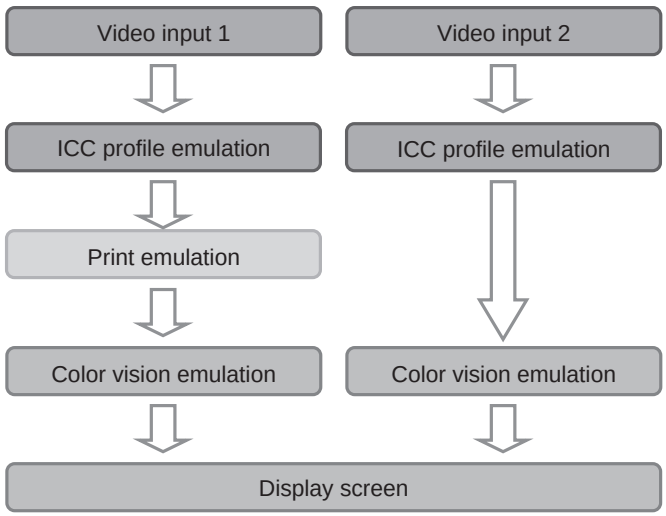

Fig. 5 Configuration of color emulations.

individuals (P/D/T/contrast, though the way the colors look varies between individuals).

The three emulations described above can be selected and combined freely, thereby making it possible to reproduce complicated display conditions such as “the visibility of a person with type P color vision viewing printed matter illuminated by incandescent lighting,” as required for art museum application. The emulations that have previously been executed using dedicated software are now available regardless of the software. The ICC profile can also be used to reproduce the color tones of display or printer that the user already owns.

(2) Real-time preview

The MultiSync ® PA Series is capable of splitting the display screen for displaying different emulations simultaneously. One of the most significant features of this function is the capability of displaying the results of different emulations of a single image as well as the simultaneous display of different images (**Fig. 6**). The highly precise display performance makes it possible to check and compare the different two color settings during the content production, e.g. colors simulated with color vision characteristics, or finely differentiated color tones to be reproduced in printed matter. This function is based on a new concept assisting the actual field image production and is able to improve the work efficiency by reducing the labor in offline production checks and rework.

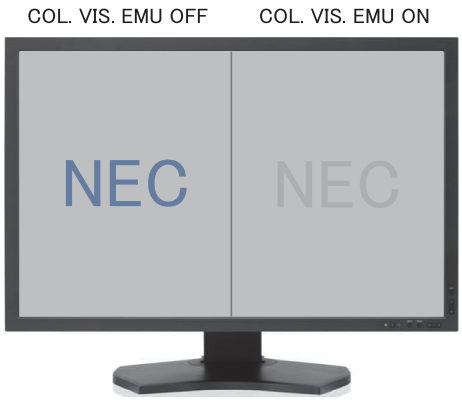

Fig. 6 Image of color vision emulation.

(3)Software linkage

MultiProfiler ® software is included for the simplified management of the display settings and the computer's color management settings. It can send an ICC profile selected by the user to a MultiSync ® PA Series display as an emulation target and, in addition, generate an ICC profile based on the color setting of a MultiSync ® PA Series display.

This software allows the alignment of color tones across multiple displays easy by setting a single ICC profile as the emulation target for all of the displays.

Users who have already utilized color management are ensuring display quality by calibrating multiple displays using a single color sensor. The MultiSync ® PA Series is compatible with SpectraView ® II calibration software for calibration. With SpectraView II, the MultiSync ® PA Series can meet the requirements of even demanding users who perform color management by continuing consistent color management.

4. Conclusion

The MultiSync ® PA Series has been developed in order to allow a wide range of customers to benefit from the effects of color management while maintaining existing needs for calibration. In the future, we intend to promote color management based on this development so as to continue to enable content producers to create and view the content in the way that they imagine.

In closing, we would like to express our gratitude to Associate Professor Kei Ito of the University of Tokyo for his valuable advice regarding color vision emulation, as well as to the Color Universal Design Organization (CUDO) and to Mr. Koichi Iga of that organization.

*SpectraView is a registered trade mark of the Habilis Corporation in Japan.

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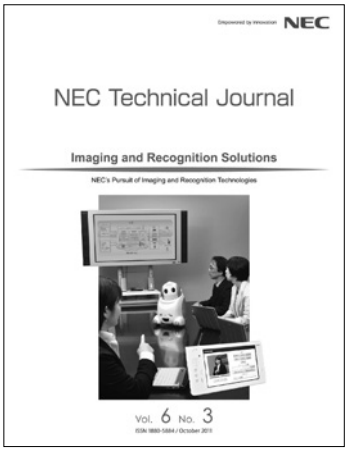

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