Memory-Color Test Forms In Real World Applications

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Stephen Herron
Isis Imaging Corporation

ABSTRACT

Many images are received for distribution and reproduction without the possibility of a comparison to the source image. Image quality is difficult to measure and quantify without such a source image. However, test photographs consisting of memory colors can be compared to a remembered image. Test forms consisting of photographs of the real world are the only source of memory colors. They are used to test a graphic-arts color workflow. Such tests:

- • Display the color quality of various output devices.
- • Describe color differences by comparing the difference between reproduction of a test photograph and the remembered colors.
- • Help achieve a preferred state of color reproduction.
- • Characterize reproduction gamut problems of an output device.
- • Remotely trouble-shoot a color workflow.

The human visual system cannot provide a precise measurement of quality but does provide direction and goals for a correction process. The criteria for the selection of image content and the usefulness of test photographs are described.

Keywords: Memory color, gamut, colorimeter, human visual system

1. INTRODUCTION

1.1 Memory color characteristics

Memory colors are not colors measured with colorimeters or spectrographically mapped. They are colors that require a context. Memory colors are the colors of grass, sky and autumn leaves. They are not the colors green, blue and orange. Memory colors are processed by the human visual system (HVS) and stored as memories.

Memory colors have the following characteristics.

- • They consist of very small gamuts. The red hue of a rose is not a memory color because a rose has too large a range of hues. On the other hand, it is difficult to view a daytime sky without seeing its small gamut of blues.
- • They are self-referential. Memory colors are described in relation to global color information, and more importantly, they are described in a context. The scene provides the HVS with processing information.
  • Information about the color is as important as the color. Our memory of flesh tones is very accurate. A tan color is only a color, but a person's face describes a particular range of tan colors. The person's face informs the HVS of its facial colors.
- • The more familiar the viewer is with the pictorial content the more accurate the color quality evaluations.
  • Memory colors are cultural dependent. The Inuit living in the artic should be better at assessing highlight colors of snow and ice than a society living in a region without winter.
- • Language, and hence vocabulary, is an important means of describing color. The color accuracy of a scene is described with words. The more words that are available to describe an object's representation, the more exact the quality comparison. Memory colors are described with comparative adjectives. Descriptions such as *too* warm, *very* dark and *low* contrast are representative.

Memory colors are not the colors we remember of a day spent on a beach. They are the combined memories of many observations. Like remembered vacation days, memory colors tend to be slightly more saturated and color balanced toward a primary axis than real-world colors.

1.2 Memory colors and the human visual system

Printed content can be differentiated into two classifications of information: one describes the exterior world we view and the other the world of ideas and language.[1] The world-as-we-view-it classification includes nature scenes, food and people. A picture of a sunset on a lake is an example of a scene from the exterior world. The other classification is of instructions, language, diagrams, and fonts. An IT8.7/3 chart, used to evaluate printer accuracy, is an example of an item from the world of diagrams. The world-of-ideas classification also includes words. In this case language describes the meaning of the diagram, not the visual characteristics of the diagram. For example, a pie chart, divided into A, B, and C segments, does not inform the viewer what should be the color for each segment (see Figure 1 for an illustration).

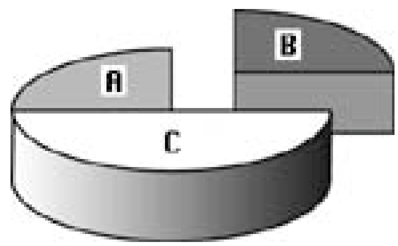

Figure 1. A typical world-of-ideas diagram

Memory colors characterize the exterior world, not of the world of ideas. Memory colors are self-referencing. That is, the context of those colors defines the colors. Memory colors cannot be isolated from the objects that reference them. When colors are viewed in isolation from their context as patches of color, they change from the world-as-we-view-it classification to the world-of-ideas, and they lose their capability to be compared to the memory of that color.

The HVS processes the exterior world through a very coarse and noisy method of receiving photons. The photon receptors, the iris' rods and cones, provide only non-continuous information of the world. The processing of the coarse information and noise removal results in very precise information.[2] The scene, consisting of objects, provides reference information or metadata to aid the HVS in processing colors. The memory of color is closely connected to the remembered object. There is no memory of color isolated from the object or scene.

The scene informs the eye of the color content of the photograph. A snow scene would consist of white and blue pastel colors. If the colors are too blue, then reproduction problems are noticed. The amount of noticeable color difference between the printed colors and the color the HVS expects depends on the importance of the photograph's content to the observer. The HVS processes the metadata and compares the printed colors with memories of similar scenes. While the comparison is not as exact as colorimetric measurements of two colors, it is the first warning that color reproduction is incorrect.

Our visual system processes each class of information differently. The world-of-ideas does not require accurate color processing by the human visual system. The HVS does require accurate edge and contrast processing in order to discern line diagrams and font edges.

The HVS relies on three types of comparisons: surround to point; one point to another, and point to metadata of the object represented. [3] There are two methods to use an IT8.7/3 chart to evaluate color accuracy – point-to-point visual comparison of two printed charts and direct colorimetric measurement. An IT8.7/3 chart alone provides very little information whereby the HVS can make accurate evaluations. Global evaluations are almost impossible.

2. COLOR TEST FORMS AND HVS

2.1 Criteria for selecting memory colors

The selection of image content for memory-color test forms fulfills the following criteria:

- • The objects closely define their colors. For example, food colors communicate the state of freshness.

- • Vocabulary is a guide to determine appropriate objects. The larger the vocabulary describing an object the greater the probability that the image contains memory colors. Many words describe human facial complexion.
- • Objects with colorations pertinent for human survival are precisely known. Military camouflage patterns consist of colors that accurately reflect the environment.
- • Objects with invariant colorations. The color of a gold wedding ring does not change by geographic region.
- • Objects with very small gamuts. The color of a yellow maple leaf in autumn.

Inappropriate types of test objects:

- • Objects with a large number of different colors. The many hues of a flower.
- • Objects with colors that change according to temporal, cultural and geographical situations[4]. The colors of animals that exhibit mimicry.
- • Objects that are not universally known. The colors of the tundra.
- • Objects that are not deemed interesting enough to be remembered. The tan color of a computer case is not a memory color – unlike the tan color of a person's face.

Color adjustment criteria to improve color quality difference recognition:

- • Adjust hue, saturation, chroma, and contrast of the photograph toward prototypical or remembered colorations.
- • Eliminate scanner noise that may distract the eye.

3.0 A REAL-WORLD EXAMPLE

3.1 Description of memory test photographs used in this test

In this test, three photographs and a test form were used to evaluate the color quality consistency between two controllers of an EP printer located at a commercial printing company. The three memory-color test photographs were scanned from large transparencies into raw data and converted to Adobe98RGB color space using Photoshop, ColorSync color management, and an ICC profile. Color correction to achieve gray balance was applied. No attempt was made to adjust color values. The photographs were approximately 8" x 10" in size. The test form, an IT8.7/3 test chart, was part of a larger GATF digital test form.

The photographs were prepared to meet PDF/X-3[5] standards. An Adobe98RGB ICC profile was attached and no compression was used.

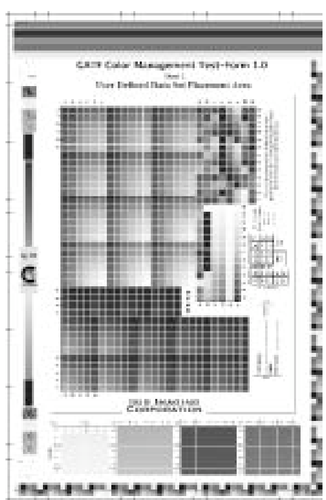

Figure 2. The GATF IT8.7/3 test chart

Figure 3. A photograph of a nature scene

Figure 4. A photograph of a light complexion person

Figure 5. A photograph of a dark complexion person

3.2 The testing procedure and results

The purpose of the test was to evaluate if two controllers, “A” and “B”, manufactured by two different companies, resulted in the same output from one EP printer. Trained prepress technicians evaluated the tests. One technician was located off site and had no direct knowledge of the printing equipment. The photographs and IT8.7/3 test chart were viewed under uncontrolled lighting conditions.

The hard copies of the IT8.7/3 chart (see Figure 2) appeared to indicate that the calibration of the controllers was reasonably close with no noticeable Delta E to the eye. In a normal working environment the visual check would not have indicated that there was a reason to measure color accuracy or to adjust either controller to achieve more consistent reproduction.

The three photographs (see Figures 3, 4 and 5) displayed considerable differences in global reproduction. The photograph of the dark-complexion person (see Figure 5) demonstrated that controller A maintained higher contrast in shadow areas, better gray balance and greater saturation than controller B. The photograph of the light-complexion person (see Figure 4) indicated that the highlights matched very well.

The nature scene (see Figure 3) demonstrated that black generation, dot gain and total ink density were also better maintained by controller A. Of particular interest, the water in the lake at the bottom of the photo displayed greater depth of clarity in controller A’s version. Dot gain and saturation increases removed much of the detail within the water when printed by controller B.

All analysis was performed by eyesight and no measurements were made. A quality category scale[6,7] was used for communication purposes. Since no source photographs were supplied, the observers did not know which of the two versions of the printed photographs achieved the best reproduction. Yet every observer selected the same printed photographs as closer to the original scene. The off-site technician’s evaluation of the test chart and memory photographs was consistent with the observations of the on-site technicians. The IT8.7/3 failed to demonstrate density gain, black generation, gray balance and saturation problems. The memory photographs succeeded at providing important information. The evaluation of the memory photographs was not dependent on location or knowledge of the output device.

The lightness, hue and chroma of the photographs were not adjusted. It is the author’s observation that when saturation is increased, contrast increased, and the chroma plane rotated toward the primary axes, then the photograph more closely approximates the remembered colors. Memory of the colorations of self-reference objects are simplified and generalized. The HVS sensitivity toward Delta E differences between reproduced colors and remembered colors becomes more acute when the colors of the test photograph closely match our memories.

3.3 The many uses for memory-color test photographs

Memory colors in test photographs can be used in a typical graphic-arts workflow to evaluate the quality and consistency of prepress, color correction, soft and hard proofing, and production printing.

- • Memory-color photographs are used to test the characterization of monitors and printers. When a color difference is observed, then a meter can be used to measure colors and the color difference metric, Delta E a*b*, used to determine the amount of difference between un-calibrated and calibrated monitors and printers.
- • Memory color photographs provides comparison information about color space and gamut relationships of each device in the workflow. With consistent color management, an analysis of the workflow can be made off site.
- • Memory-color photographs can flag color transformation inaccuracies. Proper ICC profiles can be created and used in the workflow.

CONCLUSION

Memory photographs are viewed through imperfect output devices. The determination of the quality of reproduction without comparison to a source image is common. Print customers complain that the reproduction of their photograph is not correct. Unfortunately, such criticism does not provide any information for workflow correction. It is the difference between the memory of colors and the printed photograph that communicates reproduction problems. When memory colors are considered then strategies for recalibration and characterization can be made.

Memory colors make possible remote evaluation of color accuracy without comparison to an original. The HVS evaluation of color quality is the result of a complex process of recognizing colors as they are supposed to be. They allow test photographs to be self-referencing. Memory photographs are the early warning of reproduction problems. While memory colors cannot be used to pinpoint lightness, hue, and chroma inaccuracies, they do provide good global evaluations.

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