



The Chroma Zone

Munsell Color Science Laboratory Newsletter

Fall 1995

G'day Mate!

During much of August, my wife, Susan, and I returned to Australia to participate in the Colour Continuum Conference sponsored by the Colour Society of Australia and Colourways Australia (the color marketing group of the Design Institute of Australia) followed by lectures at the Royal Melbourne Institute of Technology. We were sponsored by their printing industry's Collie Trust.

We spent our first few days viewing kangaroos and magpies from our breakfast window, visiting Ballarat (the site of the Australian gold rush), and partaking in Australia's growing wine industry at the Yarra Valley.

The conference was an interesting blend of science, design, and desktop publishing. Presented paper topics included measuring CRT displays, properties of pearlescent pigments, color paradoxes in design, using color to encourage purchasing, complementary colors, color change through genetic engineering, breeding colored cotton, color education, locating basic colors in the Munsell space, art and Xerography, digital printing, ColorSync 2.0, and problems with device independent color. I presented two papers: "Advances in Color Measurement," and "Research in Device-Independent and Multi-Spectral Graphic Reproduction." There was also an instrument show including spectrophotometers, desktop scanners, and electrophotographic printers. The most useful piece of hardware appeared to be the cellular phone attached to almost every salesperson's ear!

Following the conference, I spent two days with the Royal Melbourne Institute of Technology's School of Design and Printing. They have a very active apprenticeship program for the regional printing industry. I presented lectures on the principles of color reproduction and device-independent color. We had some interesting discussions about balancing theory and applications in the classroom. It was a challenge to present lectures to undergraduate-level students with only rudimentary mathematics skills. I think it was the fastest derivation of colorimetry I have ever given: one slide with about 15 seconds of description. Fortunately, students were able to relate to problems of color matching using desktop color equipment.

Australia is a wonderful country; its color technologists, designers, and scientist are enthusiastic and probing. As with every conference, I always learn many new things. In fact, this was the first time that I took home computer programs (a color aptitude test and an interactive way of visualizing colorimetric coordinates) in addition to abstracts and vendor technical data.

-Roy

Spectral Modeling of an Ink-Jet Printer

At the Munsell Color Science Laboratory, much of our research is concerned with achieving high-accuracy color reproduction between a variety of imaging devices including scanners, CRT displays, continuous-tone and half-tone printers, and projected slides. This involves device colorimetric characterization, color-gamut mapping, and color-appearance modeling. We have recently begun the colorimetric characterization of ink-jet printers. Pilot results using an Apple Stylewriter Pro printer are described below.

The dot-on-dot halftone algorithm was selected for study. This image microstructure yields printable colors that are composed of a primary (cyan, magenta, or yellow), a secondary (red, green, or blue), black (from 100% gray component replacement), and paper. The total number of printable colors depends on the size of the half-tone cell.

Our research goal was to develop a spectral model based on a small data base (under 100 color patches). The advantage of the small number of samples is that the printer could be easily re-characterized upon changes in consumables. This model would then be inverted using the Simplex method and used to build a three-dimensional look-up table device profile.

Eight-step ramps of each color type (C, M, Y, K, R, G, B) were printed and their spectral reflectance factor measured using a 45/0 spectrophotometer. Thus, including the paper, the total number of samples equaled 57. Using the Murray-Davies equation modified by the Yule-Nielsen correction for optical dot gain, the effective dot area of each patch was estimated using nonlinear optimization with sum-of-squares spectral error as the

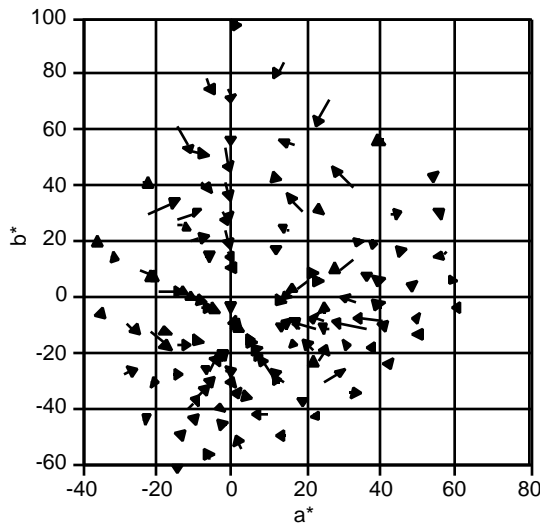
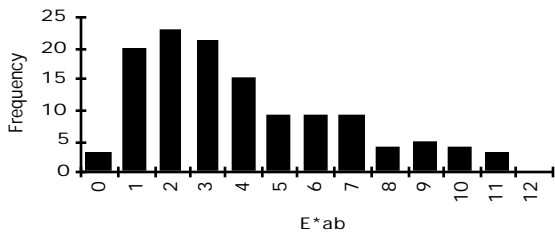
minimization function. Each set of dot areas was used to build a one-dimensional look-up table based on cubic-spline interpolation. Overprint LUTs were required as a result of increased dot gain due to paper wetting.

The complete model consisted of 1) converting red, green, and blue digital counts to theoretical dot areas of each color type using the dot-on-dot halftone algorithm, 2) converting theoretical dot areas to effective dot areas using the 1-D LUTs, 3) using the Yule-Nielsen modified Murray-Davies equation to estimate spectral reflectance factor, and 4) calculate colorimetric coordinates.

The model effectiveness was evaluated by printing 125 colors based on a 5x5x5 red, green, and blue digital count factorial design. These colors were not used to build the model. CIELAB coordinates and differences were calculated between the measured and predicted colors. A

E^*_{ab} histogram and a^*b^* vector diagram are shown below. Colorimetric error was caused by printer repeatability and misregistration, the use of a Yule-Nielsen n value that was not a function of dot area, and fluorescent quenching.

The details of this forward model and its inverse implementation into a 3-D LUT device profile is the subject of a journal article currently in preparation.



- Roy & Koichi Iino

Small Addition to the Munsell Lab

I am expecting my first baby sometime around the end of October; the tests indicate it's a boy. I will be out of the office on maternity leave from mid-October until the end of January. I hope you will be patient with Roy, Mark, and Lisa; they will be gathering their own phone messages from the answering machine and running the MCSL office in my absence. Fortunately, they will have a secretary from within the Center to help with some daily tasks for one hour each day; I believe she will be in the office from 11:00am - Noon. FYI - an effective means of communication with the MCSL staff is by way of e-mail: Roy, rsbpph@rit.edu; Mark, mdfpqh@grace.rit.edu; Lisa, larpci@rit.edu, you may want to consider this method. When I return, I will be working three days a week.

- Colleen

Color Difference Consortium Update

The Color Difference Consortium was started in late winter of this year to provide a vehicle for collaboration both intellectually and materially on color difference, being led by MCSL. We have a total of eight members involved at the present time including both companies and organizations. The consortium had decided to invest this year's efforts in a color-difference visual experiment, building on the experience of the laboratory and the need for more experimental visual data in this world of changing color difference equations. A large color difference visual experiment was carried out at MCSL in the mid-80's and was a contributing factor in creation of the CIE94 color difference equation. Although this experiment and others created a significant database, it was determined that more data would give a comprehensive study of the color space and an independent test of the existing color difference equations.

The visual experiment would employ the parameters recommended by the CIE for research in color differences. The use of these parameters created a difference from the visual experiments performed earlier by the use of a lighter surround. To clarify any differences an experiment was performed on two colors with both surrounds. The change produced no significant change in all but one of the dimensions; a mid gray color varying in lightness. We are now in the midst of the time consuming job of preparing for the full visual experiment.

- Lisa

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