Focusing on Paper Properties in Color Characterization of Printing Situations

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Abstract

The characterization of printing paper is a complex procedure involving not only the paper itself but also the various printers used. In a situation where the number of printing devices grows rapidly, there is a need for an efficient characterization procedure. The work reported here is an ongoing development of building a library of characterization procedures. These procedures can be applied to printing situations with different combinations of paper grades and printing engines. Special emphasis is put on the influence of the paper properties. Color characterization of printing devices is normally performed using color charts based on different combinations of process colors. These charts are often adapted to certain printing technologies. For an example, the IT8 color chart works well for offset printing but is certainly not optimal in all digital printing situations. The starting point in this development is the selection of a set of equidistant percepts from a homogenous color space. An example of a building block is color separation with respect to halftoning techniques and available inks or toners. Another is the characterization of the physical properties of the paper substrate.

The result of the new procedure for color characterization of printing papers correlates with existing methods. It has also contributed to a deeper understanding of the large influence paper has on the final print quality.

Introduction

Color characterizations of printing situations are essential for a correct color reproduction. Knowledge about the substrate, the printing process and the printer function are all of great importance to obtain a good color characterization. In the area of commercial printing, color charts based on the process colors, CMYK, are used to characterize the color reproduction of the process. In desktop applications colors are normally represented in RGB and printers has been developed to handle RGB data. The development of the sRGB color space has further improved the possibility of correct color reproduction in desktop applications.

New output devices are continuously introduced on the market. Along with the development of special paper for different printing technologies, a fast and accurate method for color characterization is needed. The limiting surface of the color gamut must be examined as well as the reproduction of colors inside the gamut.

There are several existing methods for describing the color gamut of output devices. This new approach to color characterization is designed to be easy applicable on desktop printing situations. The colors used for the characterization are selected from a perceptual point of view not from process color combinations. The CIELab color space was used in this model, primarily because of its geometrical properties but also because it is widely used and has a high acceptance. The printed colors are a set of equidistant percepts independent of the process colors used. The characterization procedure is therefore not dependent on the number or type of process colors used by the output device. The model has been tested on several combinations of paper grades and printing technologies.

Theory

Color characterization is normally done by a set of color patches with different parts of process colors, i.e. the IT8 color chart. In this model, colors have been selected from a perceptual point of view from the CIELab color space. The origin is a central point of the color gamut, CIELab coordinates, L*=50, a*=0, b*=0. From this point, vectors are pointing out in different directions to cover the color gamut, figure 1. The CIELab colors has been translated to sRGB color coordinates and then sent to the printer.

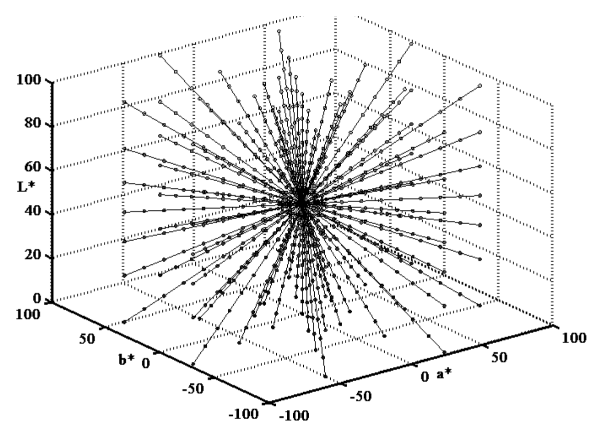

Figure 1. Vectors, pointing out in different directions to cover the color gamut

It is important that the color vectors reach outside the printable color gamut of all practical printing situations. The target color coordinates outside the gamut will accumulate at the gamut border, figure 1. The clusters indicate the surface of the color gamut for the combination of paper and printer. A new set of colors is generated around the points of the surface clusters, to improve the surface detection. Once again, the surface can be detected and now with a higher accuracy. When the gamut surface is defined, the representation of printable colors can be studied and, if needed, adjusted.

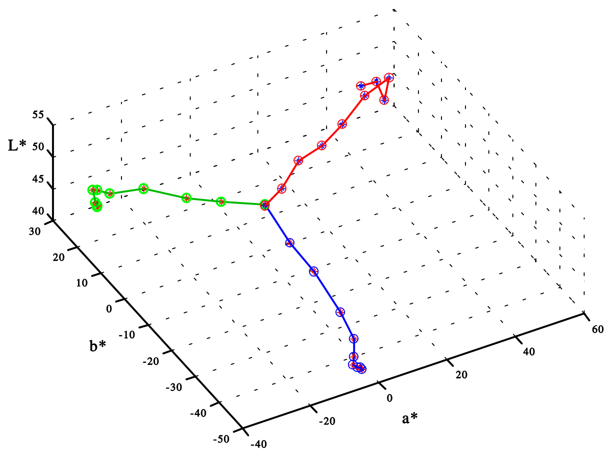

Figure 2. Three of the color vectors pointing out from the center of the color gamut, reaching the surface where the colors are accumulated

Experimental Setup

The model has been tested on several different paper grades, from plain paper to fully coated special paper. The paper grades have been printed in different output devices like desktop inkjet printers, color copier, and laser printers. All output devices had sRGB as an optional input color space. CIELab color coordinates were transformed to CIE XYZ coordinates and then to sRGB. The color charts used in this study included 2660 different colors.

The physical properties differ widely between the paper grades included in this study. Differences in coating color composition and coating layer architecture results in large differences in both ink/toner and paper interaction but also in the optical properties. The whiteness, light scattering and gloss level are all parameters showing large differences between the paper grades.

The prints were measured in a spectrophotometer with an optical geometry of 45°/0° and an observation angle of 2° and a measurement aperture of 4,5 mm in diameter. The measurements were done with D50 luminance. A polarization filter was placed in front of the aperture to minimize the influence of surface reflection on the color measurements. The color difference of the seven selected colors in figure 5 was calculated according to CIEDE94 equation.

Results

The model can detect the gamut surface in an accurate way and the difference in result from other existing methods is small, figure 3. The difference in color gamut between different paper grades are significant, figure 4. The color gamut of a high quality special paper can be up to 50% larger compared to plain paper.

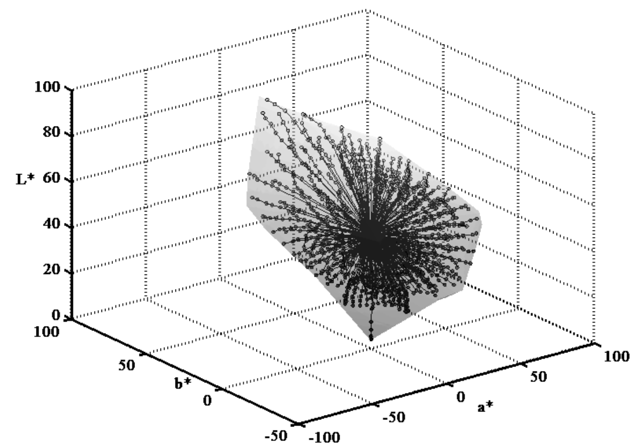

Figure 3.The color gamut of plain paper printed in a desktop inkjet printer detected both by traditional model (shaded) and by the new approach (plot).

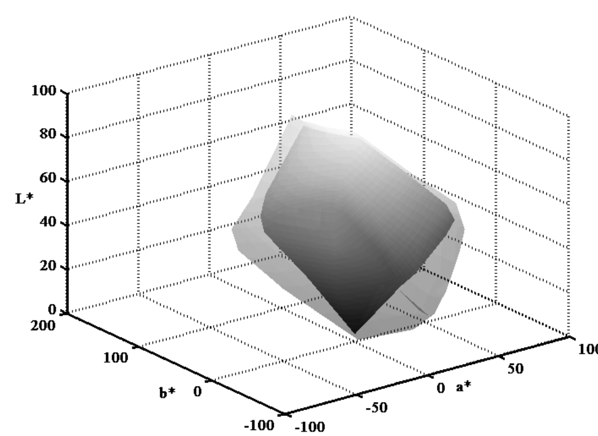

Figure 4.The difference in color gamut between plain paper (opaque) and high quality special paper (transparent) printed in a desktop inkjet printer.

Inside the color gamut the difference between desired and reproduced color was clearly visible. The color difference was bigger on plain paper compared to the high quality special paper, figure 5.

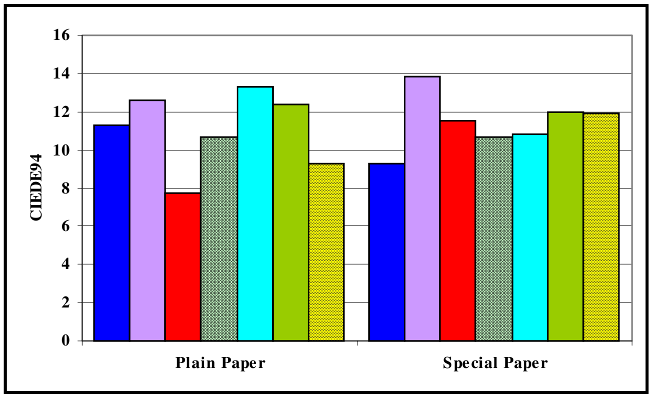

Figure 5. The CIEDE94 color difference between desired and reproduced color. Seven selected colors inside the color gamut printed in a desktop Inkjet printer on different paper grades. The color difference is noticeable both on plain paper and on high quality special paper.

Conclusion

This new model can be used for color characterization of printing paper, both in respect of defining the limiting gamut surface but also on color reproduction of in gamut colors, on desktop applications. The results correlate with other existing methods. A transfer function for the color reproduction can be calculated. With this function the color reproduction could be improved and the quality of the printed image enhanced. The influence of the paper is essential and must be included in the model. The ink and paper interaction differ between the paper grades. Many times, the choice of paper has a higher influence on the print quality than the choice of printing device. The paper properties do not only affect the color gamut but also the color reproduction. A poorer color reproduction is not only result of a smaller color gamut but is also caused by incorrect reproduction of in gamut colors.

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Biography

Ole Norberg is working with digital printing at the M-real technology center in Örnsköldsvik, Sweden, as well as a Ph.D. Student in the Digital Printing Center, at the Mid Sweden University. He has a M.Sc. in Physics from the University of Umeå, Sweden. His research interests include paper development, color science, imaging processing and print quality. He is a member of the IS&T.