Computer Aided Design of Automotive Finishes

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ABSTRACT

The principles of computer aided design were applied to the creation of new automotive finishes. A computer graphic program was written that allows the user to interactively adjust the surface reflection properties of an automotive paint and visualize the appearance of that paint on a three dimensional surface. The program gives a designer intuitive controls over a second order polynomial that defines the color of the paint at a series of aspecular angles. An automotive stylist was permitted to use the program and design three new automotive paints that had never been manufactured. Formulations for the designed paints were determined by inputting the desired aspecular measurements into an automotive refinish system. The new paints were mixed and sprayed on metal panels. Comparisons between the actual and simulated finishes were judged to be adequate by those involved in the experiment.

1. INTRODUCTION

Recent developments in computer graphic hardware and software have made it possible to provide color appearance designers with the same computer aided design tools that engineers and architects have had for over thirty years. In a manner equivalent to how wire-line drawings on the earliest computer graphic workstations allowed users to manipulate geometry in real-time, the per-pixel shading hardware and software on today's PC graphics cards provides interactive control over the spatial and the spectral distribution of light reflected from three dimensional objects. The ability to adjust how light reflects from a surface and to immediately inspect the result of those changes provides unprecedented control over color appearance and opens the door to a new type of computer aided design.

Harnessing the power of computer graphics with an appropriate user interface and passing the output from this interface directly into the manufacturing process is what defines a computer aided design tool. Computer aided *geometric* design using early computer graphics equipment required a user interface that felt natural to mechanical designers with engineering backgrounds, and it required a means of digitally expressing and storing the design so that it could be manufactured using numerically controlled milling machines. A successful computer aided *color appearance* design system implemented using the advanced color rendering features of today's graphics hardware needs a user interface acceptable to industrial designers with artistic training, and it needs a means of digitally representing the design so that it can be manufactured using chemical formulations.

This paper describes a first attempt to achieve computer aided color appearance design for automotive paint finishes. An interactive graphics program was developed that provides an automotive designer with interactive control over the color appearance of the paint. A designer from the automotive industry was invited to use the program to create three new paints that had never before been manufactured. Chemists from an automotive paint company downloaded the specifications for the designed paint, created samples of the paint, and sprayed the paint on simple
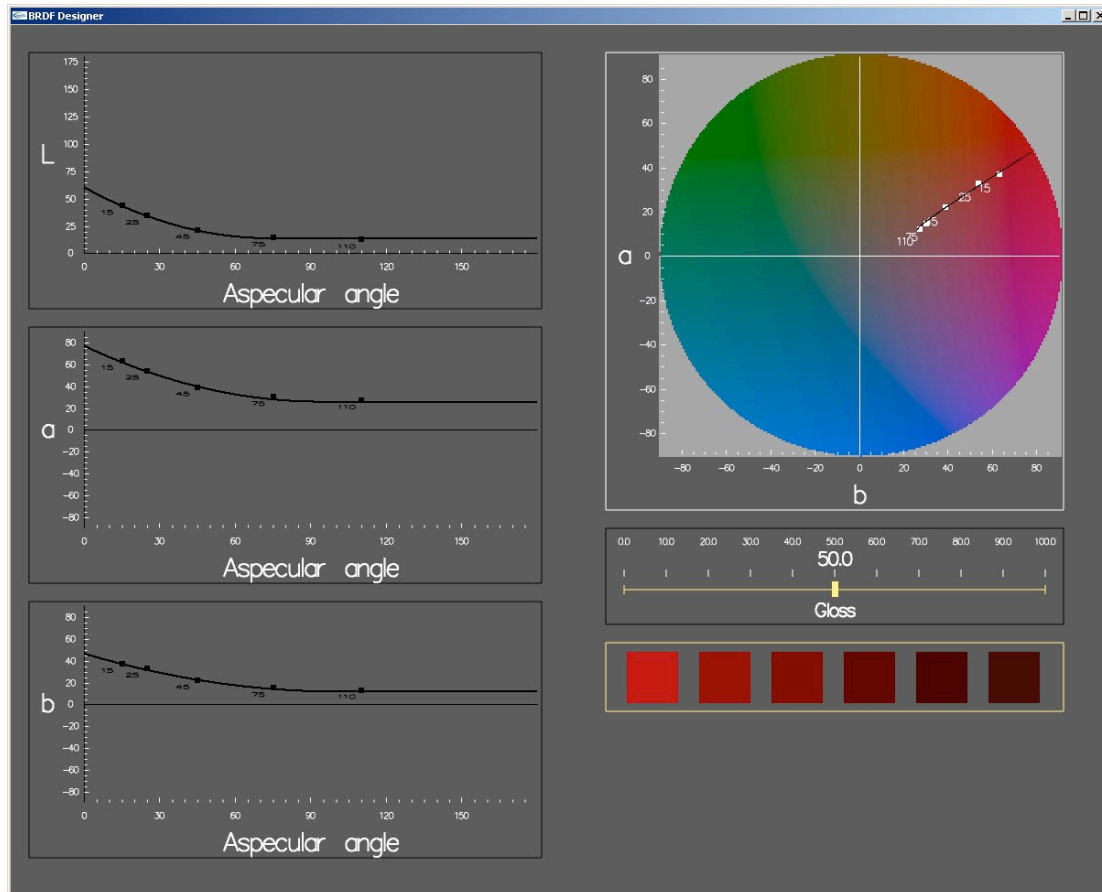
Figure 1: User interface for color design program.

metal shapes. The painted specimens were then observed under controlled lighting and compared with the computer renderings of the paint. The entire experiment was performed within a single day.

2. DESCRIPTION OF THE EXPERIMENT

The computer graphic program employed in this experiment is based on the three angle paint measurement system used in the automotive industry.[1,2] The program gives the user several different ways to adjust a second order curve (see Figure 1) that represents the color of the surface at a series of angles measured from specular (*aspecular* measurements).[3] The user can adjust the curve directly, manipulate the average hue, saturation, and brightness of the color represented by the curve, define a trajectory between a chosen face and flop color, or experiment with variations of the color displayed on simple shapes. As the user changes the definition of the color, the appearance of the color is updated immediately on a realistic rendering of a three dimensional object (see Figure 2). The aspecular measurements for the final designed color can be stored in a data file.

An automotive designer, whose job involves selecting future car colors for a major auto manufacturer, was asked to use the computer program to design three new colors. To reduce the design space to a manageable size and to increase the chance of manufacturability, an existing automotive color was used as the starting point for each design. The stylist then employed the controls provided by the program to adjust each of the colors and create a new automotive finish. The first color design used the hue, saturation, and brightness controls from the user interface to rotate the hue of a dark metallic color from blue to green (see Figure 3). In the second and third design exercises the ability to pick the face and flop color of the design was exploited. Two new colors with color travel were invented: a light blue metallic and a red metallic with gold highlights.

Once the new paints had been designed, the next step in the computer aided color appearance design process was to manufacture the paint. The aspecular measurements for each designed paint

Figure 2: Computer graphic rendering of designed color appearance.

were downloaded from the computer program and were transferred to the refinish system of a major automotive paint supplier. The computer program for that refinish system was then used to mix a paint that matches each of the three designed colors. While it was possible to closely approximate each of the colors, it was not possible to achieve an exact match. In the case of the dark green metallic the hue and saturation of the face color could not be realized. As a result the travel of the actual painted surface has a more constant hue than the designed color (see Figure 4). The final red and blue paints also varied from the designed colors but the differences were less pronounced. The Lab b value far from specular was too large for the red paint and the Lab L value near specular was too large for the blue paint.

To complete the experiment the painted samples were compared against the computer graphic simulations. The samples were illuminated by following the recommended standard, SAE J361,[4] for evaluating automotive surface finishes. The specimens were placed on a neutral gray background and they were illuminated using a D6500 area light source. The computer graphic images were displayed on 20 inch Dell Ultrasharp FP2000 LCD monitors with the white point set to D6500. The color profile for the monitor was used to convert the calculated color for the samples into the color coordinates of the LCD display. Both the samples and the LCD monitor were viewed in a darkened room (see Figure 5). Informal visual comparisons were made by color professionals between the color samples and the computer graphic images. The match was judged to be satisfactory by the automotive designer and color technologists who participated in the experiment.

3. CONCLUSIONS

This experiment demonstrates that it is possible to achieve computer aided color appearance design for automotive finishes. An interactive graphics program was written that allows the user to adjust the appearance parameters of an automotive paint in real time. An automotive stylist with responsibility for selecting new car colors was able to use the unique interface of the graphics program to design three custom paints with novel color appearance properties. The design parameters of these three paints were digitally transferred to a paint refinish system, and samples of the paint were mixed and applied to simple cylindrical shapes. The samples were observed under standard lighting conditions and were visually compared with both the original design and the final paints on an LCD monitor. The specialists involved in the experiment concluded that the match achieved was adequate for use in an actual automotive production environment.

References

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3. Clement Shimizu, Gary W. Meyer, and Joseph P. Wingard, "Interactive Goniochromatic Color Design," in *Proceedings of The Eleventh Color Imaging Conference*, pp. 16-22, (2003).
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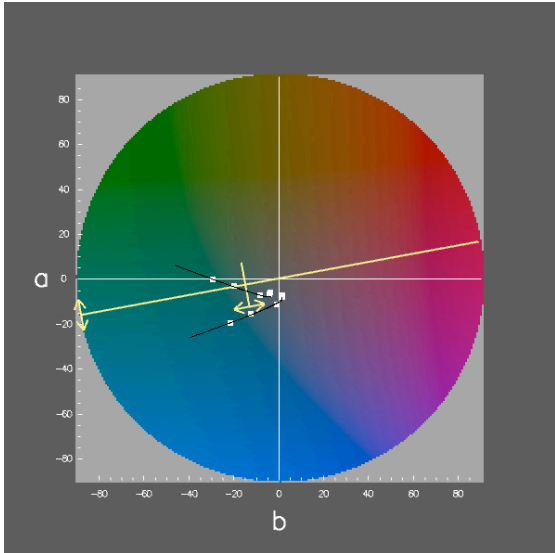
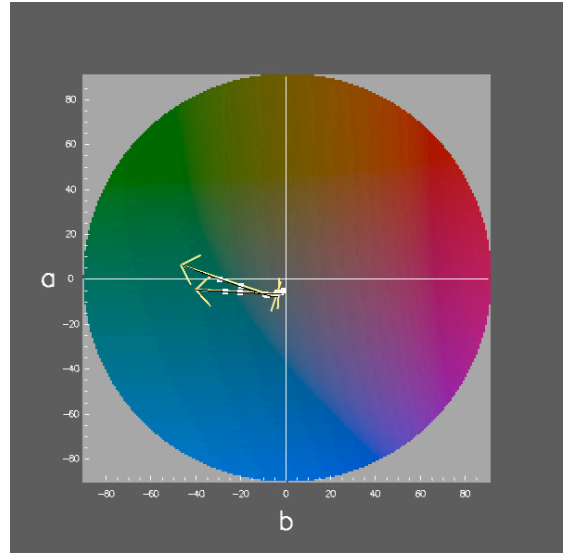**Figure 3:** Constant hue rotation of aspecular locus from blue (bottom line) to green (top line).

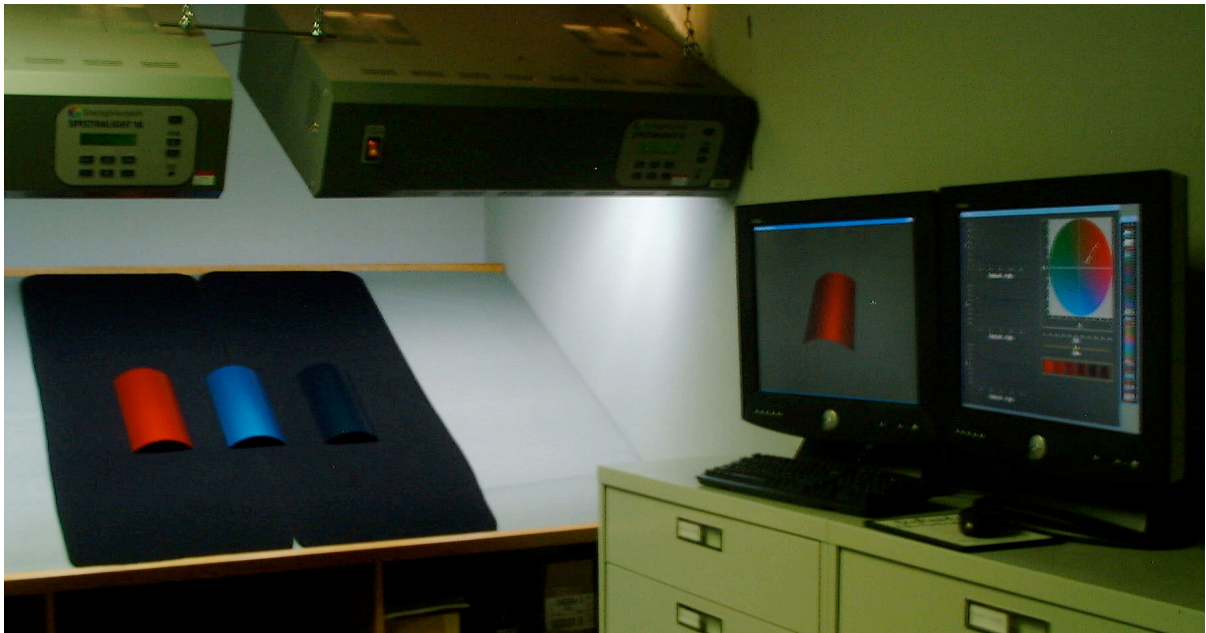**Figure 4:** Trajectory of designed green color (top) and manufactured green color (bottom).

Figure 5: Comparison between painted samples and computer simulation.