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Enhancement of Color Images by Modulation of the Luminous Component

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Enhancement of Color Images by Modulation of the Luminous Component

by

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A thesis submitted in partial fulfillment of the requirements for the degree of Bachelor of Science in the Photo-Science Department in the College of Graphic Arts and Photography of the Rochester Institute of Technology

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Thesis adviser: Robert M. Springer
INTRODUCTION

It is general knowledge that the human perceptual system called vision may be categorized by two subsystems, the achromatic and the chromatic system. The achromatic system may be described as the mechanism that detects brightness information in a scene. In the C.I.E. system this would correspond to the value for capital Y. It is usually called the Luminous Efficiency of the Eye or the Photopic Response of the Eye, and is a function of wavelength as seen in fig. 1.
The chromatic system intern, detects color information in a scene, and may be defined by saturation and hue or by capital X and Z in the C.I.E. system.

It has been proposed by some visual psychologists that sharpness information is received by the achromatic mechanism. If this is the case the portion of a visual image that transmits the spatial or sharpness information is the same as that which transmits the brightness information. This is the radiation transmitted or reflected by the image and weighted by the Luminous Efficiency of the Eye. It would seem logical if one were to attempt to enhance the spatial information in an image he would enhance the luminous component.
OBJECTIVES

The purpose of this exercise is to investigate the effects of luminous component (the radiation transmitted by the image weighted by the Luminous Response of the Eye) enhancement on color images. As there is great differences in the color and spatial quality of scenes, it is necessary to investigate a number of scenes that reflect the major types that would be commonly reproduced. It is also necessary to have a test image from which quantitative information, that indicates the physical changes in the images, can be measured.

The final objective of this exercise is the psychological testing of the images and the correlation of these results to the physical data received.
EXPERIMENTAL

The investigation was done using Kodak film type: Ektachrome Duplicating 6120 tp reproduce the images containing chromatic information, and Kodak film type: Ortho Scanner 4152, to reproduce the achromatic information.

The original transparency was a 8" X 10" composite made up of 4" X 5" scenes. The scenes were chosen in an attempt to represent the possible scene chromatic, spatial, and subject matter encountered in photographic reproduction. This of course is not possible with three pictorial scenes, but the original is an attempt at this. It contains:

1) a portrait scene
   a) 80% human content
2) a pictorial scene
   a) 20% human content
   b) low and high chromatic information
   c) high and low frequency spatial information

3) a pictorial scene
   a) no human content
   b) high light information
   c) chromatic information

4) a test object
   a) color patches
   b) a gray scale
   c) edges (both chromatic and achromatic)
   d) resolving power targets
   e) a sinusoidal M.T.F. target varying in both contrast and frequency
   f) half-tone screens
   g) half-tone images

From this original an array of degraded originals was produced. They were degraded by flare and blur.

The flare being produced by a white light exposure after
the image forming exposure. The blur being produced by sandwiching a piece of glass between the original and the duplicating material. Preliminary experiments determined the levels of flare and blur used. (see fig. 2)

<table>
<thead>
<tr>
<th>BLUR</th>
<th>0</th>
<th>1/8&quot; 3/8&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLARE</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4%</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 2

From each of these originals using a modified H.C.M. Hell Color Scanner a luminance negative was produced.

(see appendix for description of this process)

The luminance negative is a \( \gamma = -1.0 \) reproduction of the
luminous information in a scene. (see fig. 3 for a

graphical representation of this)

![Graph showing density vs. density](image)

Fig. 3

When this is combined in registration with the

appropriate originals the result is an image that

varies only in chromatic information and has a constant

level of achromatic information. These originals with

a negative luminance mask are contact printed onto the

color transparency material to produce "chromanance"
images. Three copies of each of the positions on the array of originals were made.

Using the unsharp masking provision of the H.C.M. Color Scanner to produce a spatial enhancement of the positive luminance component. An array of enhancements of the luminous component were made. (see fig. 4, a detailed explanation of the unsharp masking mechanism of the H.C.M. Color Scanner may be found in the appendix)
The analysis is a combination of quantitative physical and quantitative psychological measurements. This has not been completed in a rigorous form due to time limitations. Some observations have been gathered in a non-rigorous manner. They follow:

1) The effect of original print sharpness on the amount of apparent enhancement is large. If you have a very sharp crisp image a large amount of spatial enhancement will have only a small amount of visual effect on the observer. If, however, the original image is not sharp the effect of spatial enhancement can be very great.

2) This same type of effect may be observed when viewing the images under varying contrast conditions. If, for example, a pair of images, one enhanced and one unenhanced, are viewed in
a darkened room with a high light level in the viewer. The apparent difference will not be as great as if there were a supplementary light source in the room. The supplementary light source produces a source of veiling glare and reduces the apparent contrast. Under these conditions, where the images are of lower apparent contrast, the effect of spatial enhancement is much greater.

3) It became very apparent that the choice of the best image was not always the sharpest one. This was demonstrated by the visual effect of spatial enhancement on portraiture. In this case the images degraded in blur actually were more pleasing to view than even the originals.

4) In some circumstances where there is a large amount of sharpness information in the presence of chroma the spatial enhancement of the image will yield an increase in the apparent saturation of the chroma.
CONCLUSIONS

The effect of luminous component enhancement is strong. It is not desirable to always have the maximum amount of sharpening possible and in some cases it might even be more desireable to degrade the images by blur.

There appears to be an interaction between spatial enhancement and apparent saturation. This should be subject to a much more complete study.
APPENDIX

The Hell Color Scanner

The H.C.M. Hell Color Scanner is a device used mostly by the printing industries, for the manufacture of separations for reproductive processes. It is (as seen in fig. a) a microscope, that has mounted in the eye piece, four photo-multiplier tubes. It is focused on a rotating drum and has its horizontal position determined by a lead-screw. As the drum rotates picture information is read by the three color sensitive photo-multipliers through a small aperture and black and white picture information is read through a large aperture to yield an unsharp masking signal.

These four signals are combined in the color computer and may be manipulated to form four separations. They are the cyan, magenta, and yellow separations
and the black separation. The signals are then compressed or expanded to compensate for the characteristic curve of the film. These signals are then read back one at a time to form the four final images.

This is not, however, the mode that the scanner was used in. As the only concern was the production of luminance images, and the addition of an unsharp masking signal to the luminance image. For this the output of the photo-multipliers was adjusted to yield a photopic response. To obtain this a neutral density filter was placed in the path of the blue sensitive photo-multiplier. It was possible to adjust the other outputs by the conventional adjustments on the machine.

A major part of the work was concerned with the production of the unsharp masking signal to be used in the spatial enhancement of the images. This signal
Main Assemblies of the Machine

READING

USM
RED
GREEN
BLUE

RECORDING

COLOR COMPUTER

USM
RED
GREEN
BLUE
was blurred optically and subtracted from the black printer signal, the combination being an enhanced luminance signal.