An Opponent Process Approach to Modeling the Blue Shift of the Human Color Vision System

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Introduction

Low light level affects human visual perception in various ways. Visual acuity is reduced and scenes appear bluer, darker, less saturated, and with reduced contrast. We confine our attention to an approach to modeling the appearance of the bluish cast in dim light, which is known as *blue shift*. Both photographs and computer-generated images of night scenes can be made to appear more realistic by understanding these phenomena as well as how they are produced by the retina.

The retina comprises two kinds of photoreceptors, called *rods* and *cones*. The rods are more sensitive in dim light than are the cones. Although there are three different kinds of cones with different spectral sensitivity curves, all rods have the same spectral response curve. Consequently, rods provide luminance information but no color discrimination. Thus, when the light is too dim to fully excite the cones, scenes appear desaturated. The *opponent process theory* of color vision [Hurvich and Jameson 1957] states that the outputs of the rods and cones are encoded as *red-green*, *yellow-blue*, and *white-black* opponent channels. We model loss of saturation and blue shift in this opponent color space.

Previous Work

In 1985, we produced a comprehensive computational model which, among many other things, takes into account the perceived color at low levels of illumination [Upstill 1985]. This component of our model processes images to appear as if they were viewed at night by desaturating and blue-shifting the image. Here, we improve on our earlier model by calibrating it using psychophysical data from [Hunt 1952].

Recently, Thompson et al. presented a technique which, like ours, produces night images by taking into account desaturation and blue shift [Thompson 2002]. Also like us, they used Hunt's psychophysical data to calibrate their blue shift. However, they transformed colors using an ad-hoc set of equations, whereas our formulation derives from physiological knowledge of the human visual system [Hurvich and Jameson 1957].

Method

The purpose of our work is to apply Hunt's blue-shift data to our own model, which differs from Thompson's in that it works in a biologically inspired color space where the two color channels represent *opponent colors*: a yellow-blue color channel and a red-green color channel.

Once in the opponent color space, our method shifts the yellow-blue channel into the blue direction while simultaneously scaling down both color channels to produce desaturation. We use psychophysical data from [Hunt 1952] to match our "blue shift" results with what is experimentally observed. Our blue shift model as published in [Upstill 1985] contained manually controlled parameters; here, we replace those constants with psychophysically valid values.

Results

Figures 1 and 2 show examples of images before and after processing by our blue shift model. In Figure 1, a photograph of a real scene is used and Figure 2 is based on a computer-generated image.

Figure 1: *Original photograph (left); blue-shifted photograph (right).*

Figure 2: *Computer generated image (left); blue-shifted image (right).*

References

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