CALIFORNIA STATE SCIENCE FAIR
2004 PROJECT SUMMARY

Name(s)
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Project Number
S1520

Project Title
Quantifying the Effect of Tungsten Illumination on Color Rendering of Low-Pressure Sodium

Abstract

Objectives/Goals
Low-pressure sodium vapor (LPS) is efficient and astronomer-friendly lighting, but its narrow band of emissions results in poor color rendering of illuminated objects. This experiment determines whether a model can be developed to predict the amount of broader-spectrum incandescent illumination required to supplement LPS in order to render near normal color perception.

Methods/Materials
Using a digital camera, I took over 1600 images of six Newtonian color targets illuminated by 4300 lux from an 18-watt LPS lamp and variable lux from a 100-watt tungsten lamp, ranging from 0 to 3080 lux regulated by a dimmer and measured photometrically. I developed a C++ computer program to convert RGB pixel data of each CCD image into CIE L*a*b values and to calculate delta E color differences against a 100% tungsten color reference. I established a "Color Rendering Value (CRV)" from 0-100 for each sample, based on a weighted average of the delta Es of the Newtonian spectrum. CRVs of samples were averaged and graphed to determine a best-fit mathematical correlation to CRV as a function of tungsten percentage.

Results
The CRV for illumination with 2.5% tungsten was 2.3, 3.4 with 15.0%, 13.7 with 26.0%, 30.1 with 35.9%, and 41.2 with 42.7% tungsten illumination. A model correlating tungsten percentage, "W", to color perception as indexed by CRV was derived: CRV = 38 arctan(.07 W - 3.2) + 49.5, with acceptable color rendition at CRV > 13.

Conclusions/Discussion
The results of this experiment indicate that LPS lighting augmented by approximately 26% tungsten illumination may render near normal color perception, with higher standards achievable with higher amounts of tungsten illumination. Applications of LPS combined with broader-spectrum illumination may present an alternative for outdoor lighting that is both color-acceptable as well as cost-efficient and environmentally responsible.

Summary Statement
This project examines the effect of tungsten illumination on color rendering of low-pressure sodium vapor light using computer analysis of CCD pixel data and derives a model correlating color perception to percentage of tungsten.

Help Received
Thanks to: Christian Luginbuhl at the US Naval Observatory for access to archives. John Hoot, computer scientist/astronomer, for information about CCDs. My dad for teaching me C++. Bruce Lindbloom, color scientist, for color analysis tutorials and encouraging my pursuit of LPS photometric research.