Color Camera Characterization with an Application to Detection under Daylight

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Abstract

A technique for measuring the spectral sensitivity curves of color cameras is described. Details on the difficulties that might be encountered in such measurements are discussed. These are mostly related to the non-ideal behavior of cameras, and the properties of the quasi-monochromatic light that must be presented to the camera. The usefulness of these curves is illustrated on a specific example: that of detecting colored objects of known spectral reflectances under daylight illumination conditions.

Keywords: color camera, characterization, spectral sensitivity, physics-based vision, color detection, daylight

1 Introduction

In this paper, a technique for measuring the spectral sensitivity curves for each channel of a color camera will be presented. These curves are useful in applications requiring precise color measurements, such as in some quality control and detection tasks. The aim is to discuss the basic issues involved in doing such measurements, and to present a procedure for performing them.

Camera spectral sensitivity characterization for color research has been discussed in recent times by other authors. Based on work by Sharma and Trussel [1], Barnard and Funt [2] have developed a method in which the camera views the color samples of a chart (Macbeth color checker) illuminated by several different spectra. For each spectrum and color sample, the spectral content of the light reflected back by the sample (the stimulus) and seen by the camera is measured using a spectroradiometer. At the same time, the camera R, G, B responses are stored. The relationship between these responses and the spectral content of the stimulus is linear and given by the camera spectral sensitivities. The authors present an optimization approach for inverting this relationship, thereby obtaining the spectral sensitivities. A similar method has been described in [3] in order to map the color responses of a camera to the CIE $L^*u^*v^*$ color coordinates.

Closer in spirit to the present work is that of Vora *et al.* [4], where the camera is stimulated by monochromatic light obtained from a monochromator. The difference between the approach of Vora *et al.* and the present, is that here the monochromatic stimulus is directly sent onto the sensor, whereas in [4], the monochromatic stimulus is sent onto a white standard, with the camera looking at that standard.

The content of the paper is as follows. In the first section, some important facts about color cameras will be discussed. This is adapted from work by Novak *et al.* The motivation is that real cameras deviate from idealized camera behavior, and this must be taken into account while measuring the spectral sensitivity curves of a given camera. More generally, these facts should be known to anyone making use of a color camera for computer vision purposes, since they have consequences on the quality of color images, and also influence the efficiency of algorithms that rely on ideal camera behavior. Of major interest in this respect is the linearity of the response of a camera to the amount of light that impinges on it. A method for characterizing this linearity is explained and illustrated as well. In the second section, a measurement technique for the spectral sensitivity curves is discussed in detail with emphasis on important issues related to the properties of the monochromatic light required. Finally, in the third section, the usefulness of having the spectral sensitivity curves of a given camera is illustrated in a specific example[1].

2 Facts about Color Cameras

The problems that can occur in real color images caused by non-ideal behavior of color cameras have been thoroughly

[1]Note: The color images in this paper are available by anonymous ftp at ftp.cim.mcgill.ca from the directory pub/people/berube/VI99.