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The goal of computational color constancy is to recover the physical properties of surfaces and illuminants from photosensors responses. Color constancy can only be achieved if prior information about the physics of image formation is incorporated into the recovery procedure. Previous work (e.g. Buchsbaum 1980; Maloney and Wandell, 1986; D'Zmura and Iverson. 1992) has led to constancy algorithms based on deterministic linear model constraints. The linear models specify the classes of surface reflectance functions and illuminant spectral power distributions the recovery procedures can handle.

Algorithms based on deterministic linear model constraints tend not to be robust with respect to violations of the assumptions on which they are based. We reason that improved performance can be achieved by reformulating the computational color constancy problem as a statistical estimation problem. (A similar conclusion has recently been drawn by D'Zmura and Iverson, 1993). Rather than assuming deterministic linear model constraints on surface and illuminant functions, we assume that the likelihood that any particular function will occur in a scene is governed by a prior probability distribution. In particular, we assume that surface reflectance functions are drawn from a probability distribution induced by placing a multivariate Normal distribution with known mean and variance over the weights of a finite dimensional linear model, and similarly for illuminant spectral power distributions. We use the standard bilinear model (e.g. Brainard and Wandell, 1992) to compute the relation between surface reflectances, illuminant spectral power distributions, and photosensor responses. Following the approach described by Freeman (1993), we apply Bayes' Rule and derive an analytic expression for the marginal posterior distributions for either surfaces or illuminants. We convert the posterior distributions to point estimates by finding their means or maxima.

Interesting features of our approach include the fact that sensor noise may be incorporated naturally into the computation of the posterior distributions and that the resulting algorithm allows estimation of the overall illumination strength in addition to its relative spectral power distribution. We present our analysis and use simulation to compare the performance of the Bayesian color constancy algorithm to that of previous deterministic methods.

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