Computational mechanisms of colour constancy

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ABSTRACT

The challenge of perception arises because the retinal image provides ambiguous information about the physical properties of a viewed scene. In the case of object colour, the ambiguity arises because the object's surface reflectance is confounded with the illuminant's spectral power distribution. Many modern accounts articulate the principle that human vision resolves the ambiguity by matching its processing to the statistical structure of natural images. There are few examples, however, where this principle has been used to develop a quantitative account of psychophysical measurements. This paper provides such an account. First, we develop a Bayesian algorithm that estimates illuminant and surface properties from the retinal image. The algorithm resolves ambiguity in the image through explicit priors that represent the statistical structure of spectra in natural images. These priors provide a parameterization that allows us to control the algorithm's performance. Second, we measure color appearance by asking observers to adjust the appearance of test objects, embedded in complex three-dimensional scenes, until they appear achromatic. We then develop a model for the psychophysical data by assuming that the algorithm's illuminant estimates provide the information used by the visual system to recover object colour. The model accounts for the data well. The parameters of the model that yield a good fit may be interpreted in terms of how well matched the priors used by the visual system are to the statistics of natural scenes.