International Workshop on Computer Vision, April 26-30, 2004, IPM, Tehran

Color Measurement and Invariants in Image Processing

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Color seems to be an unalienable property of objects. It is the orange that has that color. However, the heart of the matter is quite different. There is a discrepancy between the physics of light, and color as signified by the brain. Modelling the physical process of spectral image formation provides insight into the effect of different parameters on object reflectance. In terms of physics, daylight is reflected by an object and reaches the eye. It is the reflectance ratio over the wavelengths of radiant energy that is an object property, hence the reflection function for an orange indeed is a physical characteristic of the fruit. However, the amount of radiant energy falling onto the retina depends on both the object reflectance function, the geometry of the object, and the light source illuminating the object. Still, we observe an orange to be orange in sunlight, by candlelight, independent of shadow, frontal illumination, or oblique illumination. All these variables influence the energy distribution as it enters the eye, the variability being imposed by the physical laws of light reflection. Human color vision has adapted to include these physical laws, due to which we neglect the scene induced variations.

This lecture presents the measurement of object reflectance from color images. From a computer vision perspective, a fundamental question is: how to integrate the physical laws of light reflection into color measurement? The question boils down to deriving the invariant properties of color vision. Invariants transform visual measurements to true physical quantities, thereby removing those degrees of freedom not relevant for the observer. Both photometric and geometric invariance are required for a color vision system to reduce the complexity intrinsic to color images.

In the lecture, I will outline the principles of color measurement and color invariance as a well-founded method to separate color into its correlates of material reflection, being illuminant color, highlights, shadows, shading components and the true object reflectance.