Pixel contrast

There are several primary parameters of an image which contribute to contrast between one pixel and another. These primary parameters are described the following passage. Figure 1 displays graphical representation of these primary parameters of image contrast.

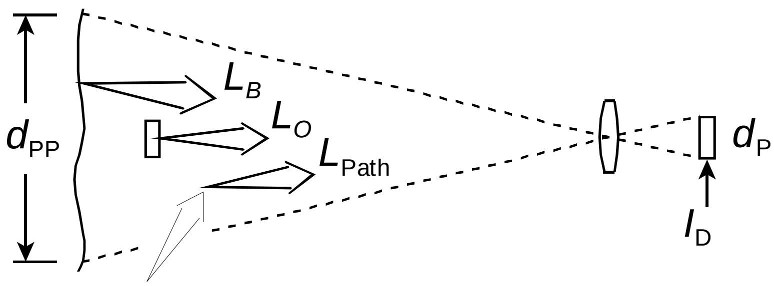

Figure 1 Sources of radiance.

The contrast of an object is defined as

$$C_O = \frac{(L_O - L_B)}{L_B},$$

where: L_O is the radiance of the object, and L_B is the radiance of the background. Radiance is power per area per solid-angle, while irradiance is power per area. Perception of brightness is normally proportional to the radiance of the object. The object contrast has a range of negative-one to positive-infinity. A bright object, such as a star, can display an extremely large-magnitude contrast which exceeds unity, while a dark object cannot. Consequently, dark objects are more difficult to detect.

Object contrast may also include the effective radiances from the path radiance and the detector as well as the spatial constraints of the detector.[1] The path radiance L_{path} represents the radiance of objects within the path of the optical system. Glare and haze are examples of path radiance. The optical noise equivalent of the detector Φ_{NED} represents characteristics of the detector such as electronic noise, dark current, offset, balance, etc. The irradiance of the detector is

$$I_D = \frac{\Phi_{\text{NED}}}{d_P^2},$$

where d_P is the dimension of the detector pixel.

The dimension of a full-pixel object exceeds the dimension of the projected pixel at the object. The contrast of a full-pixel object is

[1] G.H. Seward, "Image contrast of subpixel objects," *Opt. Eng*. **37**(2):710–716 (Feb. 1998).

$$C_{\mathrm{FPO}} = \frac{L_O - L_B}{L_B \ + \ L_{\mathrm{Path}} \ + \ I_D \ \Omega_{LD}^{-1}},$$

where: Ω_{LD} is the solid-angle of the lens-stop with respect to the detector.

The dimension of a subpixel object is smaller than the projected pixel at the object. The contrast of a subpixel object is

$$C_{\mathrm{SPO}} = \frac{\left(L_O - L_B\right) d_O^2 \, r_T^2}{L_B \ + \ L_{\mathrm{path}} \ + \ I_{\mathrm{D}} \ \Omega_{LD}^{-1}},$$

where: d_O is the dimension of the object, and r_T is the total resolution of the system at the object. The subpixel contrast applies whenever the object is smaller than the projected pixel.

As an object dimension approaches zero,

$$L_B d_O^2 r_T^2 \Rightarrow 0$$

while

$$L_O d_O^2 r_T^2 \Rightarrow D_O r_T^2$$

where the directance of the object D_O specifies the exiting power per solid angle of the object. Consequently, the contrast of a point source may be expressed as

$$C_{PS} = \frac{D_O r_T^2}{L_B \ + \ L_{\mathrm{path}} \ + \ I_{\mathrm{D}} \ \Omega_{LD}^{-1}}.$$