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Author

Cornsweet, Tom

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**Intensity-Dependent Spread - A Theory of Human Vision and
a Machine Vision Filter with Interesting Properties**

Tom Cornsweet

PULSE Medical Instruments
Irvine, CA 92714, USA

ABSTRACT

Extensive psychophysical evidence indicates that the spatial and temporal filtering properties of the human visual system depend on local retinal image illuminance; as illuminance decreases, signals are integrated over larger areas (Ricco's Law) and longer times (Bloch's Law). Those effects contribute significantly to the overall changes in sensitivity usually called light and dark adaptation.

A model that reproduces the spatial effect is as follows. There are three layers, an array of photodetectors, a "spreading" network, and an array of output channels. The output of each photodetector spreads its signals in the network, in a way to be described, and the signal leaving each point in the output array is the sum of signals arriving at that point. If the point spread function were constant, this system would simply act as a spatial filter, convolving the spread function with the input. The unique aspect of the present model is the following. It is assumed that, although the form of the excitation spread is constant (eg. Gaussian) and its center height is linear with the illuminance on the corresponding detector, its width (eg. sigma) varies inversely with illuminance in such a way that its volume is constant (thus its name, Intensity-Dependent Spread).

This model not only produces appropriate changes in spatial filtering with illuminance, but has many other, surprising, properties that mimic human vision and that are useful in machine vision. The most important properties are these: 1) for quantum limited images, the signal-to-noise ratio of the output is constant regardless of local or global illuminance level, 2) the system acts as a (non-linear) band-pass filter whose peak frequency shifts in proportion to the square root of illuminance and, 3) the amplitude of the response to an edge depends only on the ratio of illuminances across the edge.

It is further assumed that the signals spread in the network with a finite and constant velocity, the filter yields an exactly analogous set of behaviors in the temporal domain.

Comparisons of the behavior of the model and the human visual system will be presented, as well as examples of the use of the model in computer processing of natural images.