Land’s Retinex algorithm

9.35

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Land's "Retinex" theory of lightness constancy

Edwin Land founded Polaroid.

Cameras need correct exposure (both color and luminance), i.e. need to "divide out" the effects of illumination.

How do humans do it?

(Note "Retinex" means "retina plus cortex.")

The formal problem

Luminance (observed image intensity) =
Illumination (incident light) **x** Reflectance (percent reflected)

$$L(x,y) = I(x,y) \times R(x,y)$$

At every pixel you have one number, and you want to estimate two.
You can't unmultiply. It's impossible (ill-posed).
But humans seem to do it.

How?

Take advantage of scene statistics.

Scene statistics means: some interpretations are more likely than others. For instance, it is common for illumination to vary gradually over space, but for reflectance to vary abruptly (e.g., to be piecewise constant). Land and McCann used an idealized “toy world” using “Mondrians.”

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Using logs, make it additive□

Start by taking the log on both sides, making it into a simpler additive problem. Thus use log(illumination) instead of illumination, etc. We'll still call it illumination for simplicity.

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Consider it in 1-D

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Image formation is the forward process

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Vision is the inverse process.

Land's proposal: take spatial derivatives and classify them.

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If they are big (strongly positive or negative), classify as reflectance. If small, classify as illumination.

Integrate big ones to retrieve reflectance. Remainder is illuminance.

Note:
integration is a form of filling in.

How to implement in neural hardware?

One idea: use “edge detectors” in V1, which take an approximate spatial derivative.

Input

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Response

Craik-O'Brien-Cornsweet effect

Indicates the we give strong weight to edges, and not to slow gradients, in computing lightness.

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Cornsweet square wave grating

The bar centers
are the same
shades of gray.

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(Images removed due to copyright considerations.)

The emphasis on edges will make this grating resemble a normal square wave grating.

Levels of analysis

(articulated by Marr)

- Computational: what is the problem to be solved?
- Algorithmic: what approach to solve it?
- Implementation: how to actually put it in hardware.

Example 1: Calculate x/y (do floating point division).

Example 2: Compute pi.

Example 3: Do lightness constancy.

Ideas illustrated with Retinex

Levels of analysis.

Scene statistics to help ill-posed problems.

Toy world to help think through a problem.

Convergence of ideas from computation, psychophysics, and physiology.