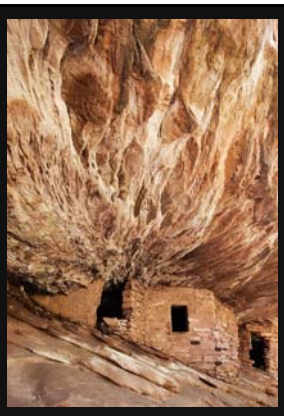


Norman Koren grew up in Rochester, NY, near the George Eastman House. Photography was a part of the environment.

Interested in photography since 12; fine art photography since 21.

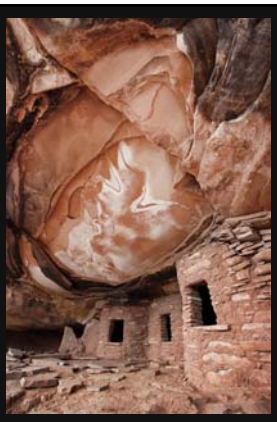
Studied physics at Brown University, Wayne State University.

Worked in magnetic recording technology (modeling, simulation) from 1967 through 2001. Pursued photography as a passsionate amateur during most of that period.

Founded normankoren.com in 2000 to exhibit images and teach techniques of digital photography. Got into technical depth in several areas, particularly image sharpness and quality.

Founded ***Imatest*** in 2004: software for measuring image sharpness and quality: www.imatest.com

Got invitation for conference while on the way to take these images in Utah.



Interests

Producing high quality fine art prints.

Developing software (Imatest) for measuring key image quality factors, including

- Sharpness and resolution (MTF)
- Noise
- Dynamic range
- Color quality
- Print quality
  - color gamut, response
  - tonal response, Dmax

Image sensor limits I

An image sensor is an array of pixels whose size cannot be made arbitrarily small for ***two*** reasons.

- ***The particle nature of light*** (Increased noise, reduced dynamic range and ISO speed)
- ***The wave nature of light*** (Diffraction: Rayleigh limit (lp/mm) = 1600/f-stop)

Moore's law doesn't apply to sensors (though it may apply to the rest of the camera electronics).

Sensors made huge leaps through 2004. Improvements are now incremental (better uniformity, etc.).

Image sensor limits II

Diffraction

f-stop	Rayleigh Limit (lp/mm)	Pixel spacing (RL = Nyquist)
5.6	286	1.75 µm
8	200	2.5 µm
11	145	3.44 µm
16	100	5 µm

To take advantage of small pixels, the lens must be diffraction-limited at the corresponding f-stop (MTF ≅ 9% at the Rayleigh limit). Difficult to achieve for large f-stops (≤ f/5.6), where lenses are aberration-limited.

Hence there is little to be gained for pixels smaller than 2 µm. *And much to be lost (ISO speed, dynamic range, noise).*