Easy Signal to Noise Ratio Measurement

S/N Ratio of Digital Camera

The signal to noise ratio (S/N ratio) of video camera is traditionally defined with analog camera measurement. Even though the definition of S/N ratio {= 20 log (saturation signal / rms noise) dB} has never been changed, the method of measurement is not clearly defined. It is especially true for digital video cameras.
Analog cameras follow mainly TV format camera noise test method, which use S/N test meter with specific band pass filter and fairly consistent to all manufacturers as long as they use the test meter. The specific issue of analog rms noise is multi-frame rms noise at specified uniform lighting, typically 1/2 of saturation (50 IRE).
Thus analog camera rms noise includes virtually everything including shot noise, which is proportional to light intensity. However it rejects high frequency and low frequency signals as well as using filer circuits inside camera.
On the other hand, digital cameras are intended to keep video data as is without filtering circuit. Therefore, regardless of fixed pattern noise or running random noise, over all noise appears in the black image (device noise floor) and there is a clear relationship to the dynamic range.
However, difficulty to obtain rms noise for multi-frame made each manufacturer use completely different values for their camera S/N ratio.
Some extreme cases are;

- Using image sensor dynamic range or S/N ratio as the camera spec
- Simply use A/D resolution (8-bit, 10-bit, etc)

Here, we will show simple and easy method to measure digital video camera noise characteristics in order to compare various manufacturers and models. It is accurate and consistent for all digital cameras.

Black image Noise Floor

Many analysis were done in imager noise characteristics and it consists dark current (thermal noise=kT noise), reset noise, shot noise, CCD surface noise (transfer noise, trap noise), output FET source follower noise. Shot noise is proportional to incident light but others make up the dark floor noise.
However, actual over all camera noise must include A/D quantization noise, circuit generated noise (amplifiers, regulators), interference noise (clock beat noise) and other electronics related noises.
To make such over all noise measurement easy, dark image noise floor measurement is the best method to get good result for comparing S/N ratio of various cameras. By using black image, shot noise can be ignored and black level pixel uniformity (blemishes) is included. We can simply capture black images with lens closed and save in raw data or bitmap.

Photoshop

Adobe Photoshop is the most popular image processing software and available to many PC users.
So, we will show how to use Photoshop to measure digital video camera noise accurately.
The process is limited to 8-bit only but if the raw data or bitmap is more than 8-bit it uses the MSB 8-bit.

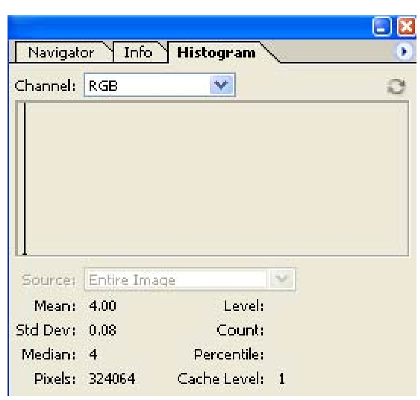
1. Save black video image in bitmap or raw data. Normally bitmap is easier for Windows environment.
2. Open the file in Photoshop.
3. Open Histogram (in Window pull down menu)
4. Select Extended view
5. Use entire field of view and measure the standard deviation.
6. In single frame histogram, rms noise and standard deviation is equal and can be applied to the standard formula of S/N ratio calculation;

S/N Ratio = 20 log (255/Std Dev) dB

Fig. shows the black level is 4.01 out of 255 (8-bit) and the standard deviation is 0.36 in the entire field of view. In this example the S/N ratio is 57 dB.

A/D Quantization Noise

In digital camera, S/N function is also limited by the A/D resolution. The theoretical quantization noise (ideal case) is S/N = 7.88 + 6.02xn (n= A/D bit). If it is 8-bit, the theoretical limit is 56 dB. GEViCAM uses 12-bit A/D and the limit is 80 dB which is much higher than sensor and camera dynamic range.



The histogram on left is typical example of GEViCAM B/W camera at factory default. The Std Dev 0.08 translates 70 dB over 324000 pixels!