Easy Signal to Noise Ratio Measurement

S/N Ratio of Digital Cameras

The signal to noise ratio (S/N ratio) of a video camera is traditionally defined with analog camera measurements. Even though the definition of S/N ratio {= 20 log (saturation signal / rms noise) dB} has never been changed, the method of measurement has never been clearly defined. This is especially true for digital video cameras.

Analog cameras follow mainly TV format camera noise test method, which use a S/N test set with specific band pass filters and is fairly consistent with all manufacturers as long as they use the test set. 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 not attenuated by the filer circuits inside the camera.

On the other hand, digital cameras are intended to keep video data as is without filtering circuits. 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 of this to the dynamic range.

However, difficulty in obtaining rms noise for multiple frames caused each manufacturer to 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 using A/D resolution (8-bit, 10-bit, etc.)

Here, we show a 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

Much analysis has been done for imager noise characteristics. It consists of 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 the others make up the dark floor noise.

However, actual over all camera noise must include A/D quantization noise, circuit generated noise (amplifiers and regulators), interference noise (clock beat noise) and other electronics related noises.

To make such overall noise measurement easy, dark image noise floor measurement is the best method to get good result for comparing S/N ratios of various cameras. By using black image, shot noise is ignored and black level pixel uniformity (blemishes) is included.

We can simply capture black images with lens closed and save as raw data or as bitmap.

Photoshop

Adobe Photoshop is the most popular image processing software and is available to many PC users.

We will now show how to use Photoshop to measure digital video camera noise accurately.

The process is limited to 8-bits only but if the raw data or bitmap is more than 8-bit it uses the 8 MSB.

1. Save black video image as bitmap or raw data. Normally bitmap is easier for the 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 are equal and can be applied to the standard formula of S/N ratio calculation;

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

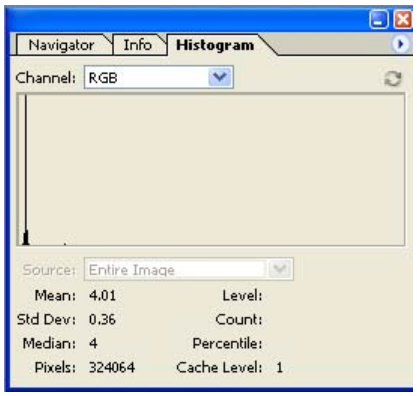
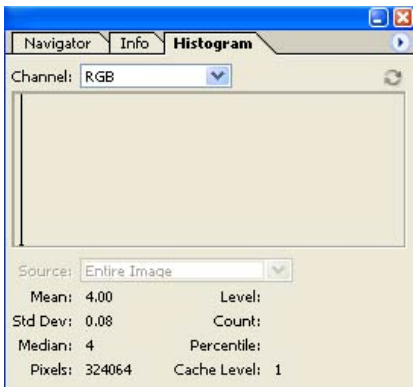


Fig. shows the black level is 4.01 out of 255 (8-bit) and the standard deviation is 0.36 in the entire field of view. In this example, the S/N ratio is 57 dB.

A/D Quantization Noise

In digital cameras, S/N performance is also limited by the A/D resolution. The theoretical quantization noise (ideal case) is S/N = 7.88 + 6.02xn (n= A/D bits). If it is 8-bits, the theoretical limit is 56 dB. GEViCAM uses a 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 a typical example of a GEViCAM B/W camera at factory default. The Std Dev of 0.08 translates to 70 dB over 324000 pixels!