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Sensor

CCD (Charge-Coupled Device)

A CCD sensor consists of an array of photocells and shift registers, which transport the charges away from the photocells. As there are different principles used for this transport, several types of CCDs can be found. All types of CCDs have in common that the charge read out sequentially, line by line, which makes this technology less flexible. CCDs have been around since the 70?s. As this technology has been refined throughout the years, further great steps in its development are hardly to be expected.

CMOS (Complementary Metal Oxide Semiconductor)

A CMOS sensor also consists of an array of photocells. Unlike CCDs a CMOS works without shift registers and allows an individual readout of the charge from any pixel. Aside from applications, such as readout of a smaller window in favor of higher available frame rates, CMOS offers a number of advantages, which will be explained in the next section. CMOS sensors did not get much attention until the 90?s. In the beginning, these sensors exhibited a raised noise level compared to CCDs. Technical advances, however, soon turned CMOS sensors into a strong competitor for CCDs, which why many camera manufacturers (especially in the still picture industry) switched to this technology.

CMOS vs. CCD

Frame Rate

Shorter electrical connections for signal transmission and power supply on CMOS sensors enable higher possible frame rates as for CCDs. The fps range in question, however, is several thousand fps. At this speed, the achievable image quality is far below what is considered to be acceptable for motion picture work, which is why a comparison of the maximum frame rate makes no sense for cinematic application.

Windowing ? Readout of a Reduced Image Area

Reading out an area smaller than the full sensor size is called windowing. This reduces the amount of information coming from the sensor and, in turn, allows capturing higher frame rates. If a camera is designed to make use of windowing, it is able to run e.g. 75 fps when using the full sensor area and 150 fps when using half of it. CCD design only allows limited use of Windowing. CMOS sensors allow readout of individual photocells and thus, unrestrained use of windowing.

Blooming

Blooming describes an effect, which makes a bright spotlight appear bigger. This effect is only occurs with CCD sensors. CMOS sensors are immune to blooming.

Smear

Smear is an effect showing a bright vertical stripe across the whole image. This effect can be seen in dark scenes with solitary glaring spots of light. CMOS sensors are immune to smear. Equipping CCDs with a mechanical shutter can neutralize this effect.

Clipping

Clipping occurs on the upper limit of the dynamic range, i.e. high exposure. Neither CMOS- nor CCD sensors offer good overexposure handling. The photocells collect their charge proportional to the amount of incident light until they reach their maximum capacity and abruptly become saturated (clipping). Differences in brightness beyond this limit will not be reproduced. Negative film stock provides more reserves for overexposure as its characteristic curve has a very soft shoulder at the top. When overexposed, differences in brightness are therefore reproduced with decreased contrast ratio rather than being cut off, as with a sensor.

Sensitivity

The amount of collected charge in a photocell is proportional to that of the incident light. This means that a smaller, fully saturated photocell offers less charge than a bigger one. Additionally, chips of the same design (same CCD- or CMOS technology) generate a noise level that is mostly independent of the amount of photocells they have. This noise level obscures the charge collected by the photocell and thus reduces the range available to create useable signals. Hence, larger photocells provide more useful signal, require less amplification and are more sensitive than smaller cells. When comparing a 6 megapixel sensor and a 12 megapixel sensor of the same size and design (e.g. 24 x 18 mm), the 12 MP sensor has twice as many photocells, each photocell half the size and the sensor half the sensitivity. Other factors influencing light-sensitivity:

- Total photocell surface area used to create one output pixel. The number of photocells combined to one output pixel depends on the type of the imager (see: Photocells).
- CCD sensors provide a light-sensitive photocell surface of approx. 70 to 100% (fill factor).
- CMOS sensors carry more circuits and have a smaller fill factor of approx. 50%.
- A camera?s sensor is located behind a number of filters absorbing e.g. UV and IR light, filtering color components, or keeping away very fine structures (spatial frequencies) to avoid aliasing. How much light gets lost depends on quality and amount of these filters.
- CMOS chips initially generated more noise, which is of no further consequence due to technical advances.

Dynamic Range

Dynamic range stands for the extent of reproducible change of brightness. As the amount of collectible light or charge depends on the size of the photocells, larger cells also provide more dynamic range. If we look at both sensors introduced above, the 12 MP sensor also delivers a smaller dynamic range than the 6 MP version.