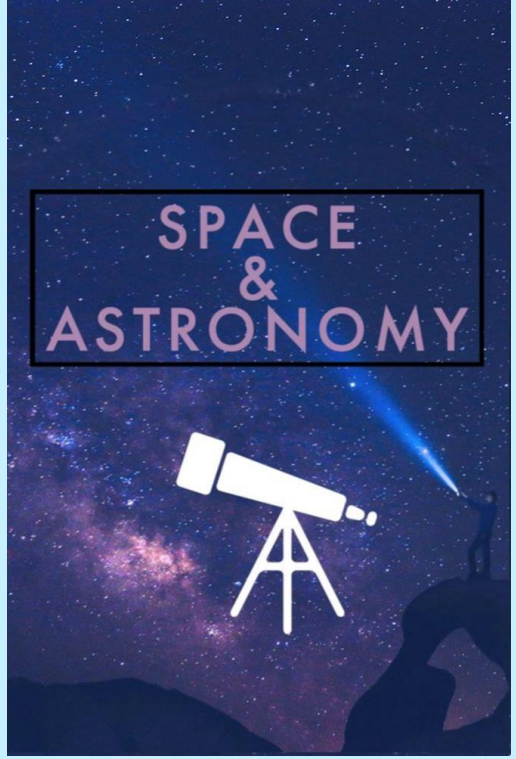

Space, Astronomy and Astrophotography

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Voices Of the World

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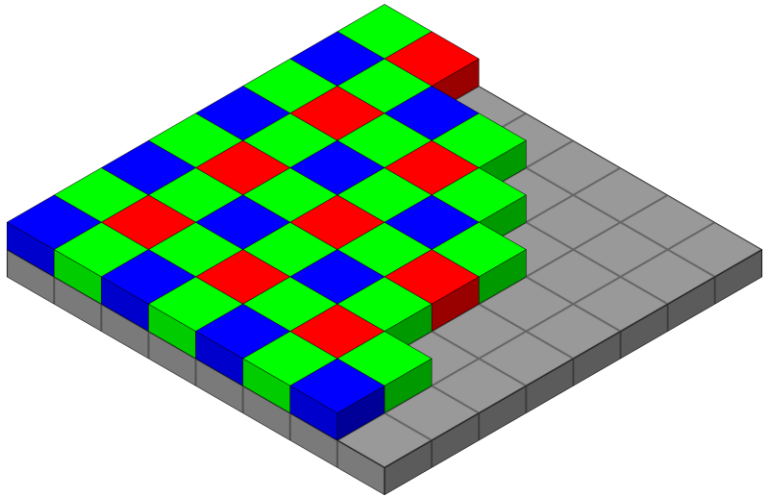
Basics of Digital Photography

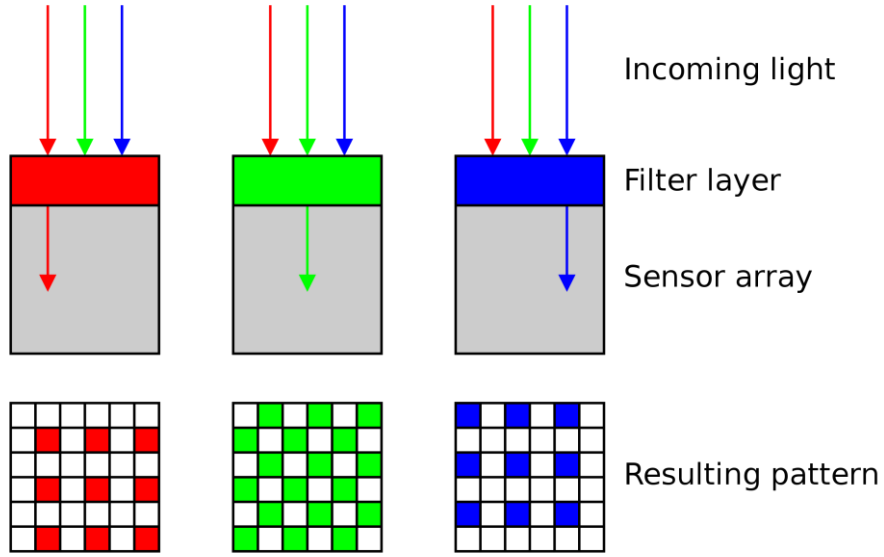
Digital Sensors
From light to electric current

- Digital cameras use **digital sensors** to collect **light** and convert it into an **electronic signal**
- Sensors are rectangular arrays of individual light-sensitive devices (the “pixels” of the sensor)
- Most sensors are either Charge-Coupled Devices (**CCD**), or Complementary Metal-Oxide Semiconductors (**CMOS**)
- The electronic signal is then **amplified** (ISO sensitivity setting) and converted **from an analogue to a digital signal**

Beyer Pattern & Interpolation

- From millions of Pixels **B&W** to millions of Pixels in **Colour**
- (Almost) All digital sensors are actually **BLACK&WHITE** sensors
- For a sensor to “see” colours, an alternate array of **coloured filters** is applied on top of it
- Through numerical **interpolation,** for each individual single-colour pixel, the two other colours are **reconstructed** using information from the nearby pixels
- Almost all camera makers use this technique, with few exceptions (Fuji, Sigma…)





ISO Sensitivity

- ISO sensitivity is a measure of the **responsiveness to light** of the light-sensitive material, be it film or a digital sensor
- In film photography, it is a **fixed property of the film**, given by the particular chemical composition, and cannot be changed.
  One may therefore buy and use *different films* with different ISO sensitivities *for different purposes.*
- In digital photography, each sensor also has an *inherent ISO sensitivity*, called the **base sensitivity**
  (typically between ISO 50 and ISO 200)
- In digital photography, the *light reaching the sensor* generates an **analogue electronic signal.** This signal can be **electronically amplified.** The ISO sensitivity in a digital camera controls the magnitude of this amplification.
- Only *after* the amplification is applied, the signal is **converted from analogue to digital.**
- **Effect on exposure:**
  1. **Low ISO Sensitivity:** *little or no amplification* is applied, therefore the sensor can collect all the light it can, before it *saturates.* This may require a long shutter speed, a wide aperture or both
  2. **High ISO Sensitivity:** *some, or a lot of amplification* is applied, therefore one can *reduce the shutter speed*, or *close the aperture*, or simply shoot when there's *very little light available*

ISO Sensitivity

- **Effect on picture look:**
  1. **Low ISO Sensitivity:** the sensor collects all the light it can with no amplification, therefore working at the *best of its possibilities.* This produces the *maximum technical image quality.*
  2. **High ISO Sensitivity:** the sensor collects a *very dim signal* which is then *amplified*. This can introduce *electronic noise*, which results in image *colour noise* and *decrease of detail and sharpness.*
- **Typical values of ISO sensitivity:**
  50 – 100 – 200 – 400 – 800 – 1600 – 3200 – 6400 …
  Every successive value represents an increase of factor 2x of the electronic signal equivalent to increasing the total exposure by a factor 2x.

Recommendations:

1. If shooting *hand held*, use always an ISO sensitivity **high enough** to ensure a fast enough shutter speed **to avoid blur by camera motion**.
2. If shooting *subjects that move*, use an ISO sensitivity **high enough** to have a shutter speed fast enough to **stop motion**.
3. **A noisy but sharp picture is ALWAYS better than a less noisy but blurred picture**
4. If *technical image quality* is a priority, use the **lowest ISO sensitivity** *compatible with the light conditions* (but always remember the points above first).
5. If shooting on a *tripod*, shutter speed is of no concern, therefore use always the **base ISO for best quality.**
6. ISO sensitivity was much of a concern 5-10 years ago; nowadays cameras got so good that even using high ISO sensitivities like 1600 to 6400 still gives good or excellent results

Analogue to Digital conversion

- Until the ISO amplification, the electronic signal is still **analogue:** it can assume any continuous value within a certain range, proportional to the intensity of light collected by the sensor
- In order to use this signal, and process it into a digital image in our computers, the signal needs to be converted into a **digital format**
- The **analogue-to-digital converter** takes in an analogue (continuous) signal, and outputs a **digital signal** (a string of bits, 0&1)
- The analogue-to-digital converter has a maximum precision depending on the **number of bits** used in the conversion (usually 8, 12 or 14).
- The higher the number of bits, the better the **accuracy** of the digital reproduction of the signal
- Higher accuracy means **more accurate and faithful reproduction** of the *tonal variations* and of *colours,* but also **larger file size**

In-camera image processing

Our current cameras (even our phones!) can implement a number of **image processing steps** to the image, after it is generated. These include:

- **Colour processing**
  White Balance: making the colours “warmer” or “cooler”
  Saturation: making the colours “stronger” or weaker/smoother
- **Contrast:** tuning the *relative intensity* between **bright and dark** areas of the image
- **Sharpness:** optimising the amount of **detail**

White Balance

- This is a **CRUCIAL** setting to control in your camera
- It regulates **the way colours look "warmer" or "cooler"**
- In principle, it should be se according to the **type of light** of your picture, to **make colours look natural**
- White balance can be set very accurately through the **Kelvin temperature scale**
- Different kinds of light include:
    1. Sunlight (5500 K)
    2. Shade light on a bright day (light from the blue sky) (7000 K ca.)
    3. Light on a cloudy day (6000 K ca.)
    4. Bulb light (tungsten bulbs) (2700-3500 K)
    5. Neon light (4000 K, different colour balance)
    6. Flash (almost identical to sunlight)
- By default the camera tries automatically to achieve the *most **faithful** colour rendition* it can… trying to guess what kind of light is there in front of you.
  Usually it does a very good job!
- White balance can be used **creatively** to achieve a particular look (very warm or very cold on purpose)
- Best setting for *night sky photography*: **WARM LIGHT (TUNGSTEN)**

File Storage
RAW and JPEG

- Digital cameras can store image files in usually 2 or 3 different types of format
- **JPEG (and TIFF)** files are "*finished and ready*" pictures.
- They are very **common, standard** image files, that anybody on any device can read and see in the same exact way.
- **RAW** files collect the bare data from the sensor.
  They are NOT "real images" yet, and still need processing in the computer
- There is no "universal" RAW file format: every camera maker has its own!

Interesting video: Phil Steele, RAW vs JPEG – The Real Truth

File Storage: JPEG

PROS:

- ***Ready,*** out-of-the camera image file, that you can use immediately and share
- ***Little or no processing*** *needed* (but you can still process them as much as you wish)
- Cameras do already a bit of in-camera processing and optimization (sharpness, contrast, saturation, white balance, noise reduction). They are usually **very good** at this!
- Anybody on any device will see them **exactly in the same way**
- Flexibility in the choice of **file size/quality trade off** (compression level)
- Great choice as a ***final output*** **file**, to share or deliver to print

CONS:

- It's a compressed format, some information is thrown away
- Chances *for image degradation* if the compression is too strong
- Can only take a **limited** amount of processing, after which they degrade
- Some of the in-camera processing is not *reversible*

File Storage: RAW

PROS:

- They contain **ALL THE INFORMATION** out of the digital sensor
- No in-camera processing applied: maximum flexibility
- The only way to get the maximum technical quality out of any camera (sharpness, noise reduction, colour accuracy ecc)
- They can be processed extensively

CONS:

- **LARGE** file sizes! This means…
  you need a lot of *memory and storage space*
  more time to *download and process!*
- Not ready files: need further processing before the image can be “seen”
- Usually, the image out of the camera looks quite ugly
- Need **special software** to be opened and processed: not everybody will be able to see it!
- Each different software will “see” the image in a different way!

File storage: recommendations

- **#1 IF YOU HAVE TO ASK, USE JPEG**!
- Use **JPEG** if:
    1. Standard *good quality* is ok
    2. You are taking *a lot* of pictures
    3. You want to keep *file sizes* acceptable
    4. You need to *process the pictures FAST*, or *not* process them at all
- Use **RAW** if:
    1. *Best quality* comes before anything else
    2. You are taking only *few* pictures
    3. You can *take the time* to process the pictures in depth
    4. You need to do *serious and extensive processing*
    5. You want the maximum possible sharpness and detail, *get the maximum out of the camera*
    6. You need to use *very high ISO and noise reduction*
- … **Astrophotography** is one of the *few cases* where **JPEG works, but RAW can be better**!

Image Credits

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