Sensors and RAW Files

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Colour and the Human Eye

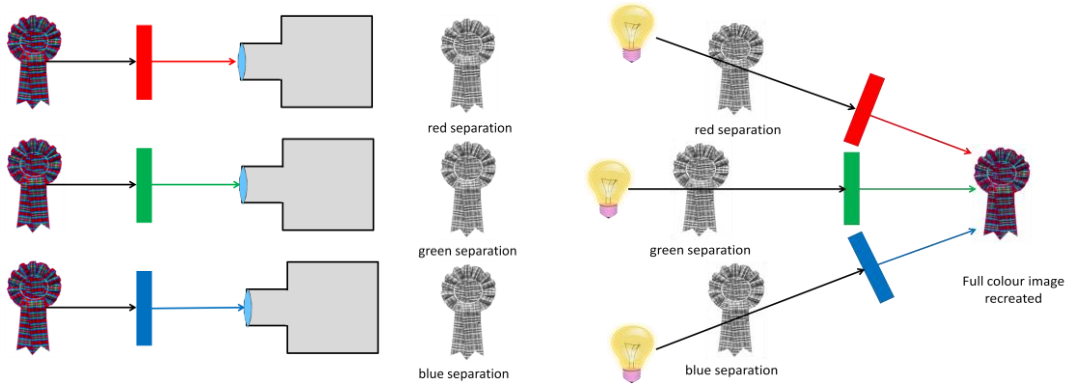
The first person to break up light into its individual colours was Sir Isaac Newton. Newton used a prism to break up the light and was able to show that this really was a property of light and not of the prism itself. This was the beginning of our understanding of the idea of a spectrum which, today, we understand includes radio waves and X-rays as well as visible light.

Based on this idea, another scientist, Thomas Young, developed a theory of the human eye. He noticed that painters could use just three primary colours. From this he suggested that the eye breaks down light into three colours.

James Clerk Maxwell (1831-1879)

Today, we know that in the centre of the retina are cells called "cones" which are sensitive to coloured light. There are three types: some are sensitive to red, others to green and some to blue.

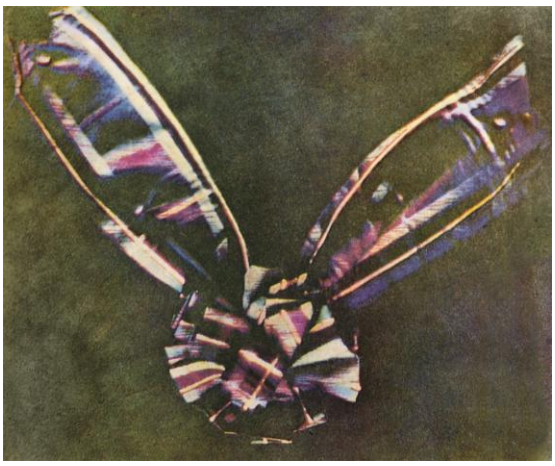
This idea was picked up by a Scotsman, James Clerk Maxwell. Maxwell was one of the great scientists of the nineteenth century (it was some of Maxwell's work which led to Einstein's Theory of Relativity.) Maxwell suggested that if the eye was actually sensitive to just three colours, then with just those colours you could simulate every colour. He was imagining colour photography.



Maxwell's Idea

He proposed that you could photograph something three times each time through a different colour filter. This would produce three monochrome images, each slightly different due to the different colour filters. You could then project those images together onto a screen, each image being projected through the filter used to create it. The result would be a full colour image on the screen.

He made his proposal in 1851. In 1861, Thomas Sutton tried the experiment. He photographed a tartan rosette and created the first colour photograph.

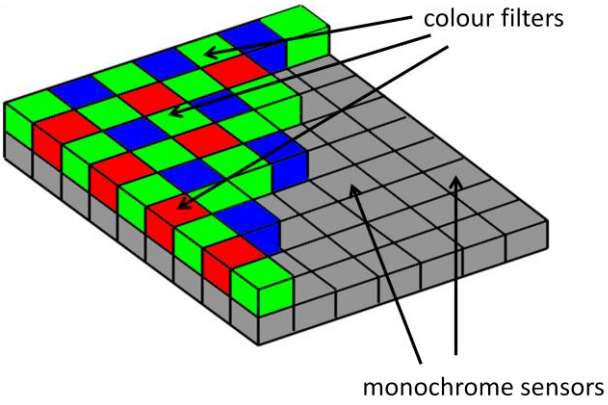


The First Colour Photograph (1861)

Chemical to Digital

The insight from James Clerk Maxell that a colour photograph can be created from just three colours lies at the heart of modern digital cameras.

Maxwell proposed taking a photograph through coloured filters. That is exactly what happens in the sensor of a modern digital camera. Light falling on the sensor passes through an array of coloured filters. The amount passing through each filter is detected by a monochrome sensor (photosite) beneath the filter.



An Image Sensor with Colour Filters

So, each photosite provides a signal indicating the amount of a particular colour which falls on that part of the sensor. There are a couple of issues here:

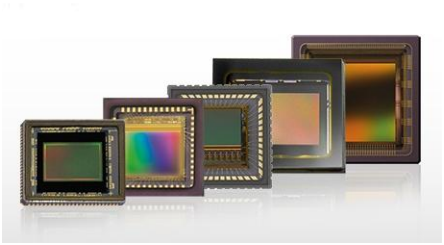
- the standard layout of photosites (known as a Bayer Matrix) means there are more green sensors then red or blue, and second;
- there are gaps in the coverage for any particular colour to allow space for the other colours.

These are well understood problems and processing on the chip can perform the necessary interpolation. The on-chip processing also includes analogue to digital conversion so the information provided by the sensor chip has already been digitised.

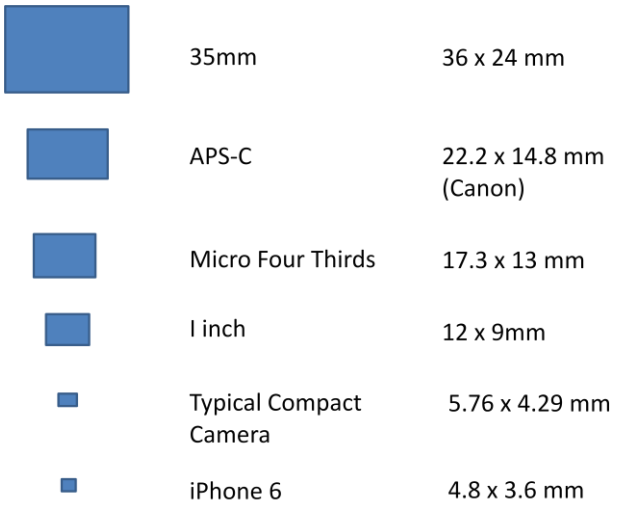
Sensor Sizes

A sensor is an electronic component. As with all components from different manufacturers and designed for different roles, there are variations. In particular size.

A small sensor need not have fewer photisites, but each photosite may be smaller and more susceptible to noise



Sensors of Different Sizes



Typical Sensor Sizes

There is a lot of rubbish talked about the advantages of large sensors. It depends what you are taking pictures for. If you are creating images to use on social media, a small sensor is fine - as millions of social media users have discovered with their phones.

Image capture

In summary, the stages of image processing which take place o the sensor are:

- photons hit the sensor
- this creates an electrical charge at each photosite
- the charge is converted into a voltage
- the voltage is converted to a number (digital)

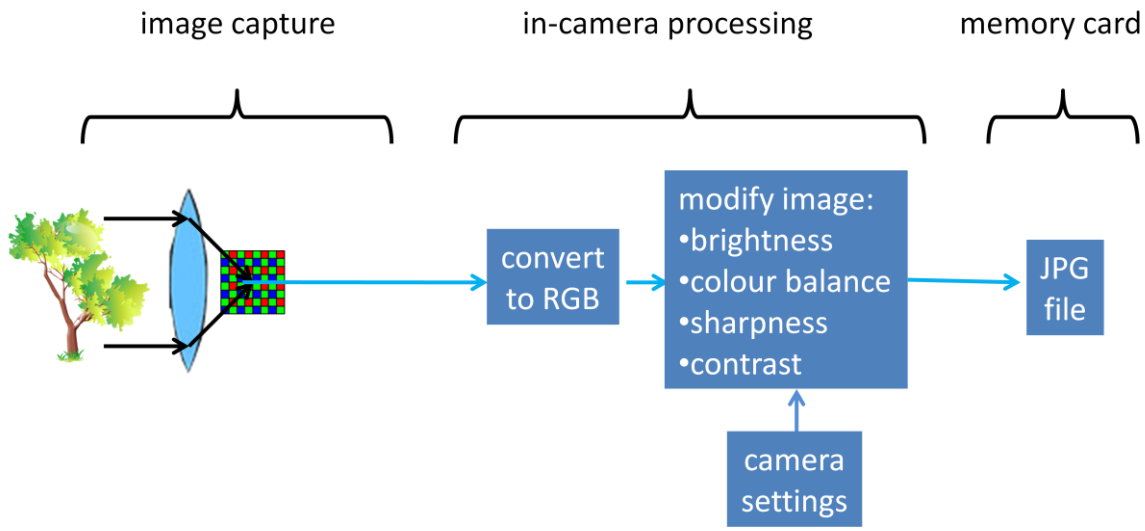
In-Camera Processing

Once the image has been captured it is converted to RGB (usually at 8 bits per channel) and the various camera settings are applied:

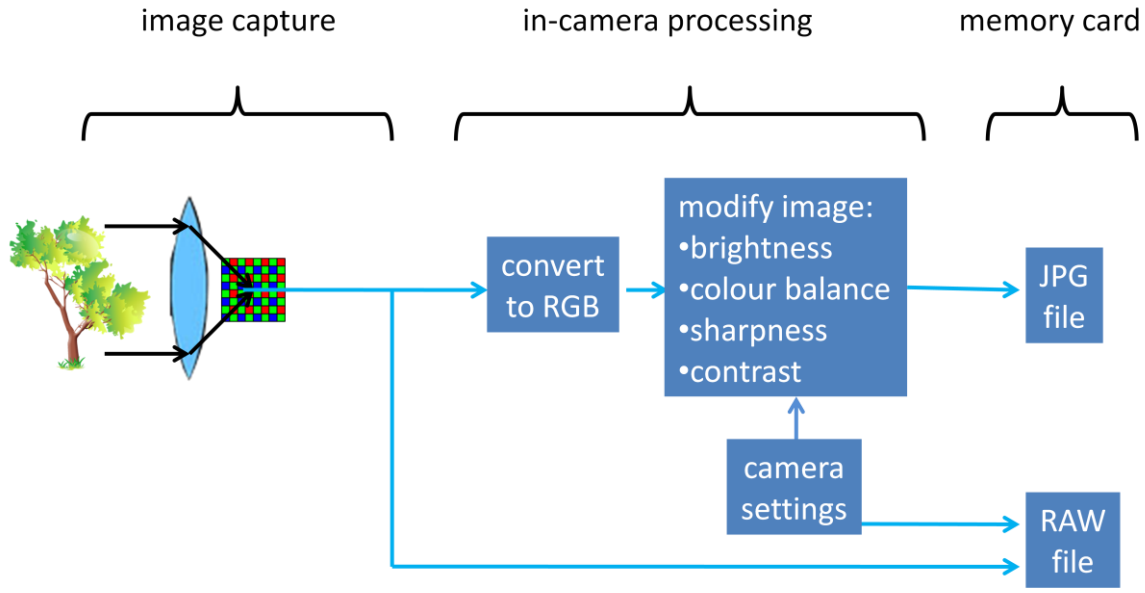
- Brightness
- Colour balance
- Sharpness
- contrast

Once these changes have been made, you can't go back. The image is converted to JPG format and stored on the memory card. That is it. You can't go back in Photoshop to change the colour balance, for example.

In order to be able to modify these details the information about the image needs to be captured at an earlier stage – before the camera settings are applied. This capture from before the image is



In-Camera Processing without RAW



In-Camera Processing with RAW

modified in camera is called RAW capture.

A RAW file captures the image data from earlier in the process –before the conversion to RGB and certainly before any changes to colour balance and the like are applied.

The RAW data contains far more information than the JPG. For example, while the JPG may be 8 bits per channel, the RAW file could be capturing information at 16 bits per channel. It is this extra information which allows more flexibility in manipulating the RAW image.

Alongside the RAW data, the camera stores the camera settings. By keeping them separate, the data is not changed and an external RAW editor can modify them and create new versions of the image with different exposure, colour balance etc.

RAW Files: Advantages and Disadvantages

RAW file advantages:

- greater dynamic range
- potential for more detail
- no JPG artefacts

RAW Files Disadvantages

- large files
- different RAW file for every make and model of camera (a new camera may mean new software!)