3 Chip or not 3 Chip, That is the Question!
Colour Imaging Techniques for Machine Vision

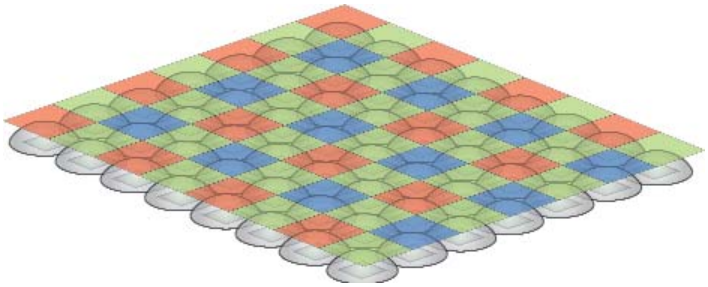
Digital Colour Imaging Techniques

Colour imaging can be a powerful tool in machine vision, but there are different ways of extracting useful colour information from the intended target scene. This Technical Tip shows you what they are, and discusses their respective merits.

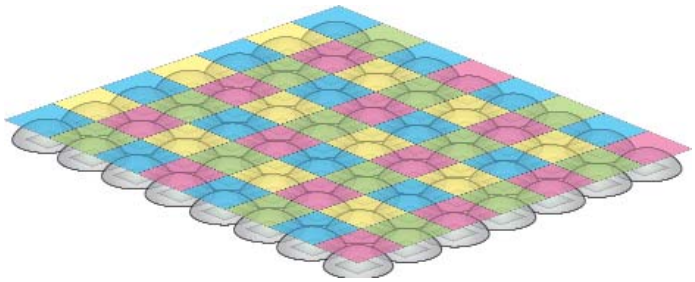
There are two main techniques for recording colour information when using machine vision cameras. All sensors, whether they are CCDs, or CMOS based devices, are inherently monochromatic, unlike the human eye, so to obtain the required colour information, either a colour mosaic filter is placed over the sensor, or the light is split into it's component colours before being directed onto 3 seperate sensors. We will now look at these techniques in detail.

Area Scan - Part 1.
Colour Mosaic Filter Techniques

The most common filter technique is the Bayer Colour Mosaic. This technique uses a sensor with a sequence of red, green and blue filters over the pixel, (see diagram below). This arrangement is often described as a 'mosaic filter'. There are typically twice as many green pixels as either blue or red. This mimics the response of the human eye and the typical information that would be obtained from an outdoor scene. To give a full colour image it is necessary to have RG and B data for each pixel, this is achieved through interpolation, either within the camera, the frame grabber or PC.



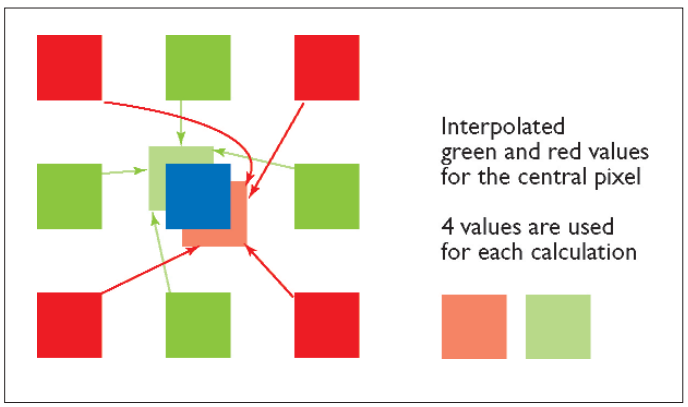
RGB Bayer Filter



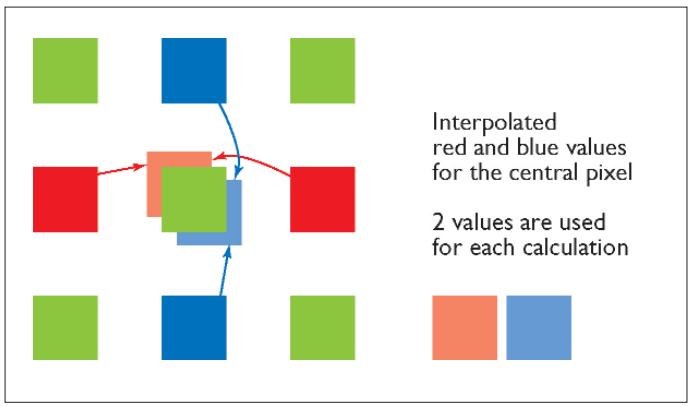
Complementary Colour Filter

There are some cameras that use 'complementary colour filters' consisting of yellow, cyan, magenta and green pixels. This type of filter array is sometimes used in CCTV cameras as the filter material is less dense and allows more light to pass through when low light sensitivity is required.

The colour mosaic filter technique generally offers a lower cost solution than a 3 chip camera and it is easier to choose a suitable lens. It is also possible to use less data transmission bandwidth by performing the Bayer-to-RGB conversion on the host PC. Typically Bayer filtering is more sensitive than 3-chip camera solution, however, filtering offers less colour fidelity and the Bayer to RGB conversion can be processor intensive to do in real time. When imaging lines and edges, Bayer filtering can introduce a particular type of distortion that is due to a lack of available information.



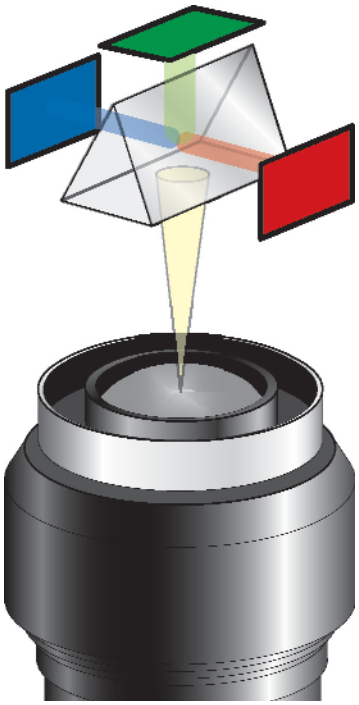
For Blue Pixels



For Green Pixels

The way pixel colour values are interpolated by using the surrounding pixels varies with the colour, as shown here. If the red or green values are sought for a blue pixel then 4 surrounding colour values are used. If the red and blue colour values are required for a green pixel however, there are only 2 surrounding values that can be used for each.

Area Scan - Part 2.
Three Sensor or '3-Chip' colour cameras



3-Chip colour cameras use a prism to split the white light coming through the lens into its red, green and blue components. A separate CCD is used for each of these colours and the outputs from these sensors are either taken from the camera separately and re-combined in the frame grabber or PC or they are re-combined in the camera to be output as S-Video, composite colour or YUV in the case of digital output.

The image shown here is a diagramatic representation of how the prism in a 3-chip camera functions in relation to the 3 sensors.

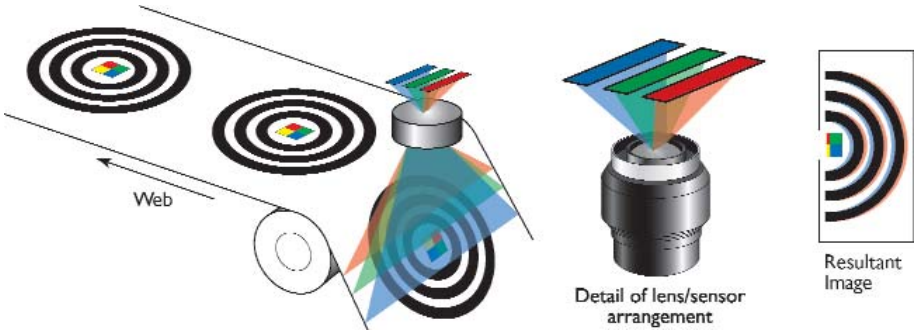
A 3-Chip camera will give the best possible colour separation and full spatial resolution can be obtained for each possible colour, however, they are typically more expensive than single chip cameras and must use RGB output for best quality.

The prism is close to the lens aperture and the lens must not protrude into the camera body. One important consideration is that the lensing should be matched to camera for best results because standard lenses often introduce chromatic aberration, leading to spatial separation between colour planes.

Part 3.
Colour Linescan Camera Techniques

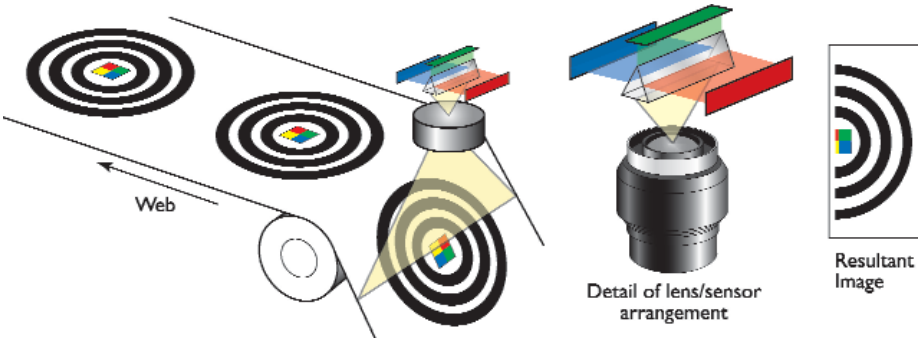
Linescan cameras are available in both colour and monochrome versions, but unlike area scan cameras, colour linescan cameras generally use 3 sensors as standard, one for each of the Red, Green and Blue colour values, and these can be arranged in two ways:

3-CCD 'Tri-Linear' Linescan



The sensors are positioned adjacent to each other, spaced by an even number of pixels, to form what is called a 'tri-linear' camera. The spatial differences between the sensors are compensated for in the software. This architecture has good sensitivity (similar to a monochrome set up) but is limited to imaging flat, 2D objects as the diagram above shows.

3-CCD 'Prismatic' Linescan



The sensors are arranged around a prism (as with 3CCD area-scan). This can accommodate 3D objects without problem as the R, G and B pixels are coincident for a given object position. The trade-off is that the introduction of a prism makes prismatic linescan cameras less sensitive.