Technical Note for Wavelength Selectivity

Wavelength Selectivity

Introduction

A **CMOS** (Complementary Metal Oxide Semiconductor) image sensor is an electronic chip that features an array of light-capturing cells (pixels) that pick up the photons at their various wavelengths and translate them into electrons, which can then be used to form an image after digital processing.

One important aspect when analysing imaging sensors is the **Quantum Efficiency**. This is a measurement of the effectiveness of the sensor to produce an electric charge from the incident photons. This efficiency can be measured in electrons per photon or in amps per watt. Since the energy of a photon is inversely proportional to its wavelength, Quantum efficiency is measured over a range of different wavelengths in order to characterize the sensor efficiency at each photon energy level. By selecting different wavelengths we can maximise image clarity, resolution and contrast.

In a CMOS colour image sensor, each pixel has its own colour filter. This allows separate measurement of the red (R), green (G), and blue (B) photons by removing the wavelengths of unwanted colours. Typically, the pixel array follows a specific pattern, like the Bayer colour filter array (CFA) pattern, which is shown in Figure 1 for pixels that are 1.14 µm square.

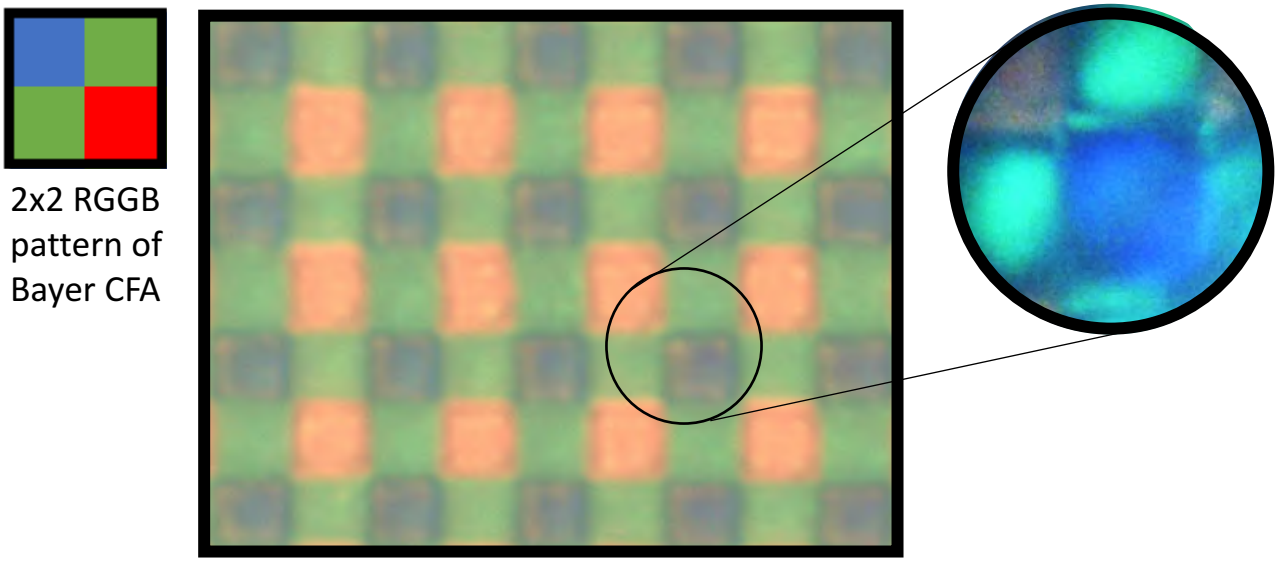

Figure 1 – Schematic of a Bayer CFA pattern (Left), and a portion of a large area scan image of a CMOS sensor with 1.14 µm pixels using Nanoro and a SMAL lens (middle) and a zoomed-in snapshot with lighting arranged to better highlight the colour differences (right).

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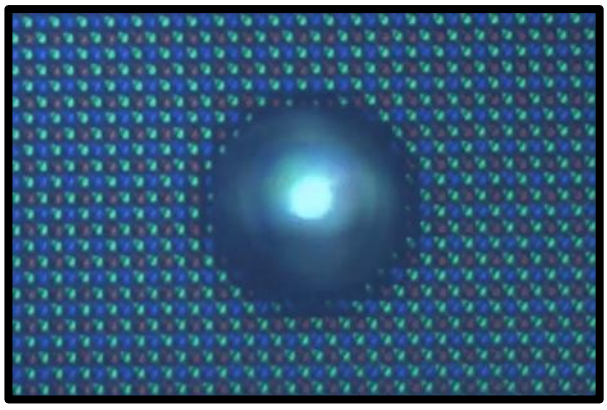

Figure 2 (left) a CMOS image sensor imaged at high resolution through the microsphere part of a SMAL lens. Figure 3 (right) focusing on the sensor with the 100x part of a SMAL lens.

Scan / click the QR code to the right to see a video of focusing on a CMOS sensor using a SMAL Lens. or visit:

https://youtu.be/AuR0pLyg-JE

NANORO Hardware

The Nanoro microscope comes equipped as standard with a high-resolution colour CMOS camera with a maximum resolution 12 Megapixels (4000x3000 pixels of size 1.55 µm) with an array that follows the Bayer CFA pattern.

Figure 4 shows the graph of the Quantum Efficiency in relation to the wavelength of the incident photon for each one of the different colours (Red, Green, and Blue). It is possible to see that for Blue radiation (at 470nm) it shows an efficiency of 67%, for Green (at 525 nm) is 76% and for Red (at 640nm) is 51% with minimal overlap at full-width, half-maximum.

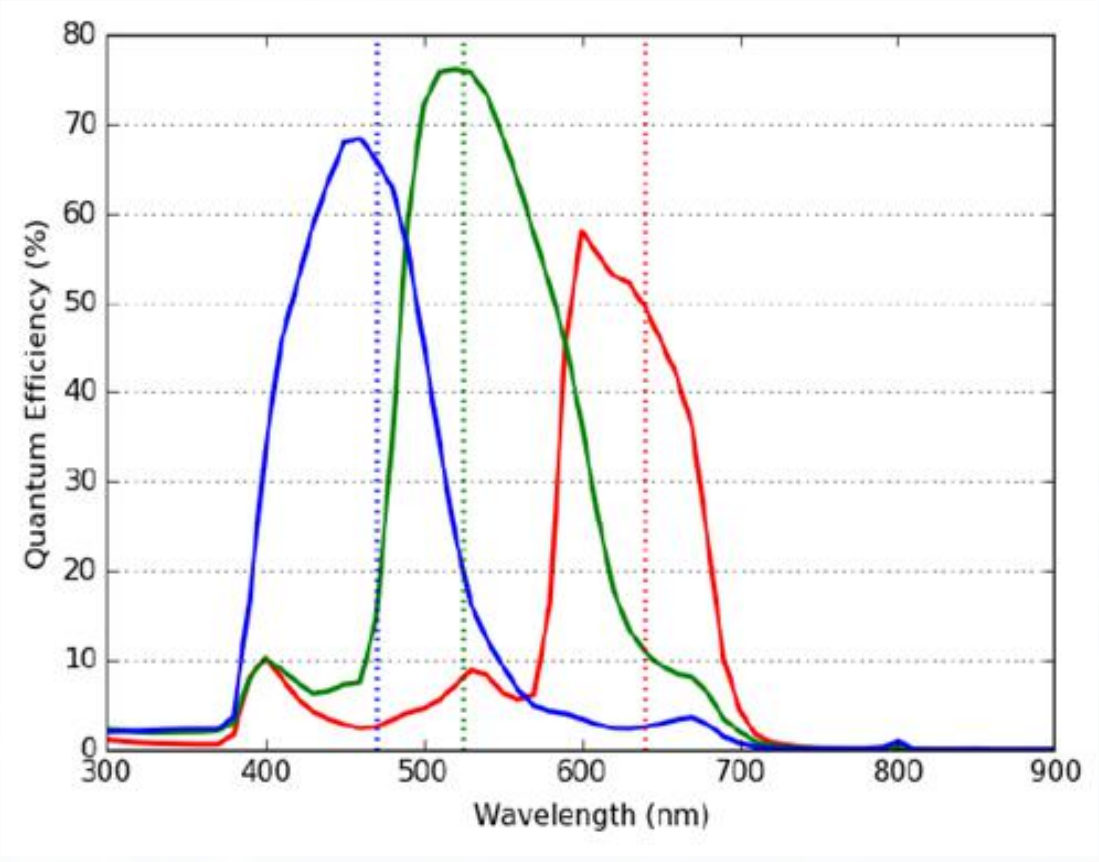

Figure 4 – Graph showing the wavelength selectivity of each colour sensor.

One feature of the Nanoro software is the ability to choose either full colour or to select one of these colour channels of the camera and use this as a form of wavelength selectivity. This can be an important tool for both sample and system characterization. (Figure 5, below)

NANORO Software

When one of the colour channels is selected, the image is shown as a grayscale image where the areas of highest (lowest) intensity of that colour are shown in white (black). This is demonstrated in Figure 6, where an interference pattern is demonstrated. By selecting the colour channel, different areas of the interference pattern are highlighted. This is performed from the user interface shown in Figure 5, right.

This tool can be applied to the microscope images to ensure that the images are in-focus for the wavelengths of interest, or alternatively, where the sample has some degree of transparency versus wavelength, that the specific region of interest is imaged at the sharpest, highest resolution. As this can be applied in real time (before image stitching), it allows investigations to be optimised dynamically before proceeding to large-area scanning.

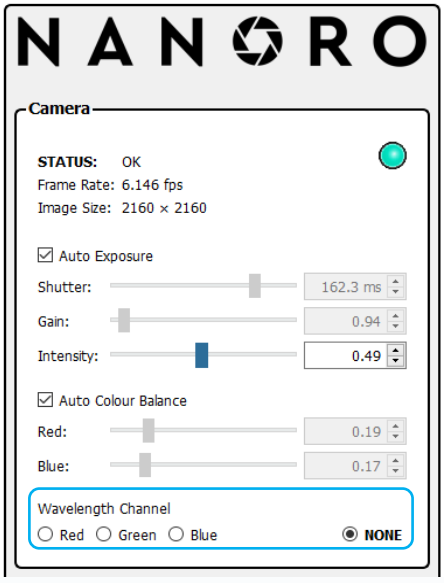

Figure 5 – Software options to select Wavelength Channel.

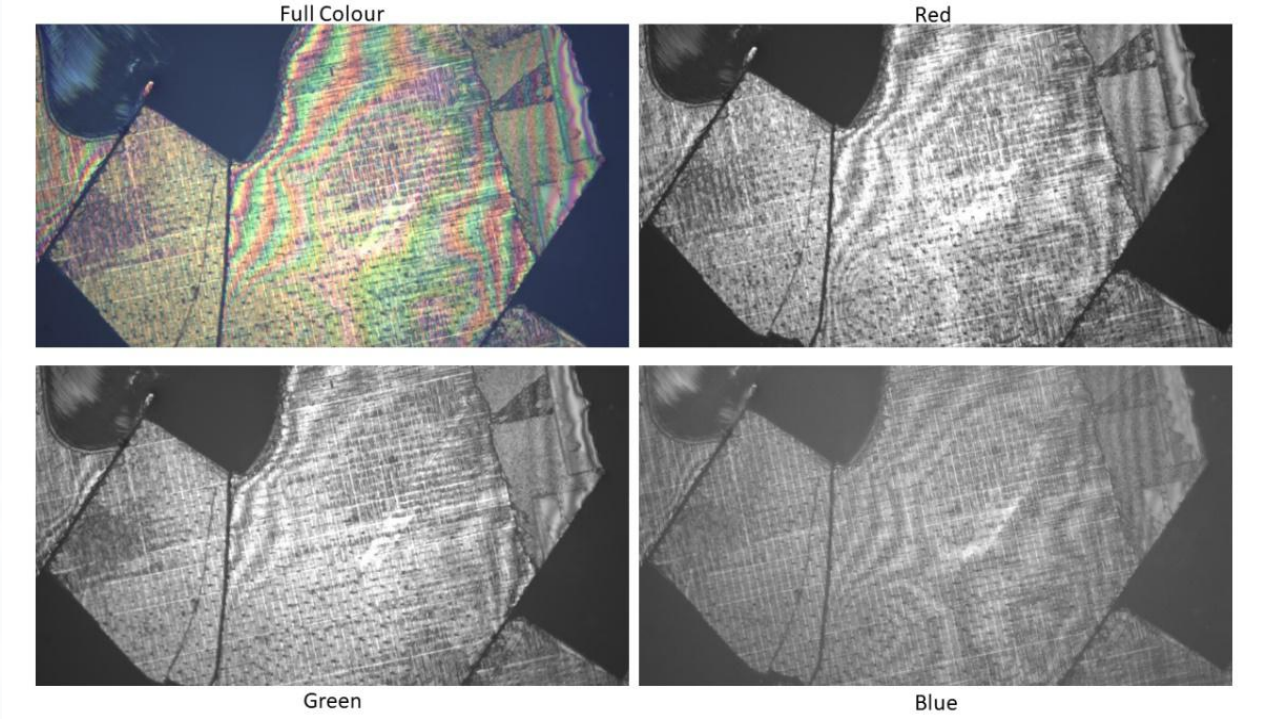

Figure 6 – Full colour and the image from each one of the colour channels of the interference pattern on a microprocessor taken with Nanoro microscope.

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