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# Color Appearances of Invisible Light by an IR Cutoff Filterless Color Camera

There are some applications which take the images using a color camera without the IR cutoff filter (IRCF) under invisible light in Machine Vision Systems, but the color appearances of these applications are rarely talked about.

Therefore, the image data of mono wavelength light (MWL) which are including UV, IR and visible light were taken by using an IR cutoff filterless (IRCF-less) color camera.

## ■ Color Cameras and IR Cutoff Filters

### Spectral Responses of Image Sensors and IRCFs

Image sensors with photoelectric conversion parts which are made of silicon have sensitivity for visible light (Vis) and limited invisible light as ultraviolet (UV) and infrared (IR) up to about 1100 nm (1.1  $\mu\text{m}$ ). Hence, general cameras eliminate IR by IRCF in order to avoid optical adverse effect to output images by IR. Further, on the shorter wavelength side, UV is absorbed by optical glass like imaging lenses in general use, so an optical filter is not used in particular.

### Spectral Responses of Color Cameras

Primarily, color cameras aim to make color reproduction more closer to the human sense of sight, so spectral responses and/or on-tip color filters of image sensors have similar characteristics. Based on the assumption that color sensors are used in Vis region, spectral responses of color sensors are generally opened to the public in the range of about 400-700 nm (Vis region).

### How to Be Used in Machine Vision Systems

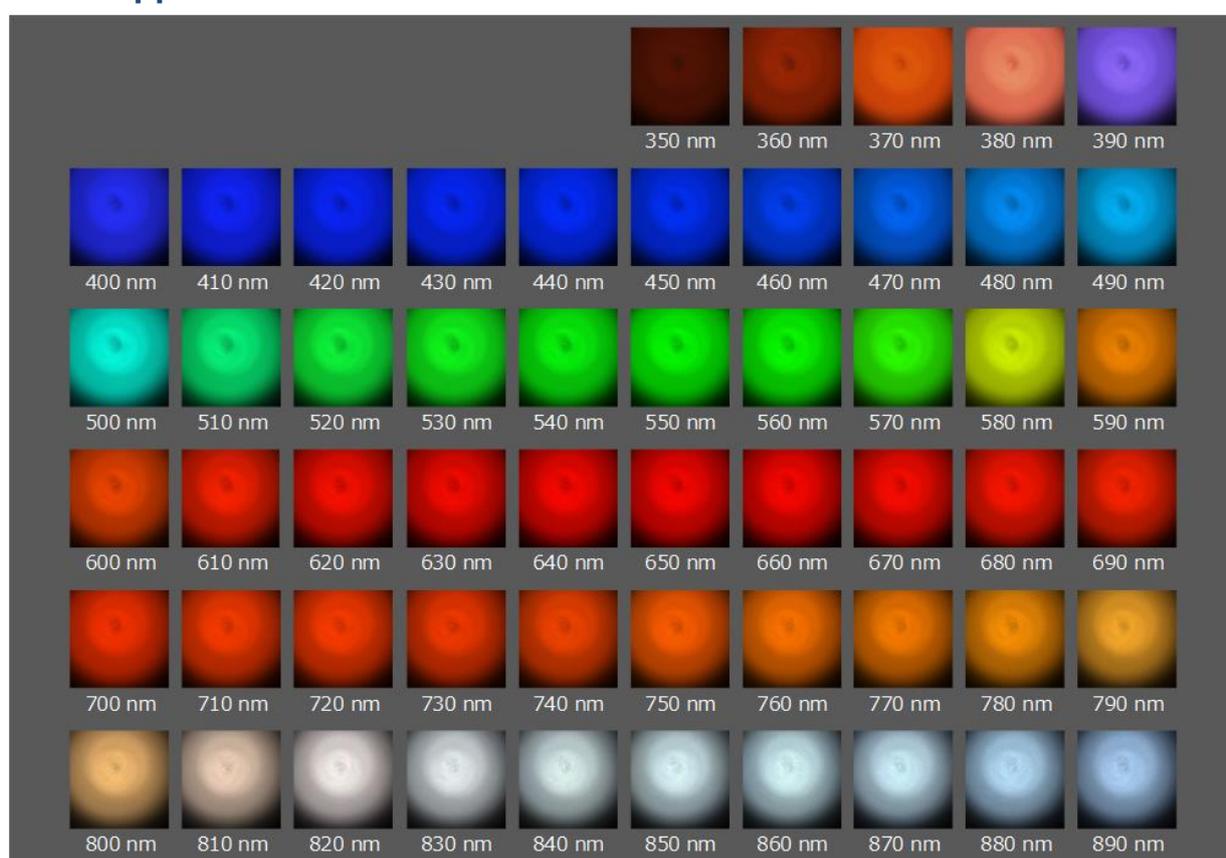
In Machine Vision market, some cameras are used without IRCF for inspection or measurement system using UV and/or IR, as well as Vis. In this case, B&W cameras are usually used since IR does not have a color as the perception. Color cameras are used in particular applications like inspections using IR in combination with Vis light, in this case invisible light is to be colored. The next section describes color appearances of invisible light by the IRCF-less color camera.

**■ Color Appearances of MWL by the IRCF-less Color Camera**

**Conditions of Taking Image data under Mono Wavelength Light**

| Item                | Equipment / Condition                      | Item                         | Equipment / Condition                      |
|---------------------|--|------------------------------|--|
| <b>Camera</b>       | BU030C<br>(IRCF-less Color Camera)         | <b>Light Source</b>          | Monochromometer                            |
| <b>Viewer</b>       | Teli U3V Viewer                            | <b>Illumination</b>          | via Light Guide<br>(cut off outside light) |
| <b>Gain Setting</b> | Gain: 0 dB<br>R Gain: ×1.0<br>B Gain: ×1.0 | <b>Wavelength</b>            | 350-890 nm, photo every 10 nm              |
|                     |  | <b>Brightness Adjustment</b> | by Exposure Time (max 16 sec)              |

**Color Appearances of MWL**



In the color appearances of mono wavelength light (MWL) , R of RGB colors is dominant than G and B around 700-740 nm. The ratio of R decreases gradually as wavelength becomes longer, so, the colors are getting whiter at the range of over 820 nm since there is no difference of sensitivities between R, G and B. On the other hand, in the UV region, B is dominant down to 390 nm. The colors are getting red-tinged under 380 nm since the ratio of B is decreasing. In addition, colors are changing drastically with respect to the wavelength between 390 nm and 380 nm (no image data).