Hyperspectral Imaging:

What is it and how does it help me?

The purpose of this paper is to provide an overview of hyperspectral imaging to those new to the technology so they can understand whether or not it might meet their imaging needs.

What is hyperspectral imaging? Hyperspectral imaging yields more accurate color and material identification by providing far more detailed information for each pixel as compared to conventional imaging such as a color camera. In contrast to a color camera that has only three channels, the light signal is divided into many tens to hundreds of bands or channels. As discussed below, this additional resolution improves machine vision accuracy, often dramatically.

Hyperspectral imaging sounds like something new, but it is really just a logical extension of conventional spectroscopy. A spectrometer spreads a light beam into a continuous band of "colors." This can be done with a prism, for example. The bands of colors taken together is referred to as a spectrum of the light beam, and the study or use of light spectra is called spectroscopy. A hyperspectral imager acts like hundreds of spectrometers in parallel, which provides a spectral curve for each pixel in a scene, as indicated schematically in Figure 1.

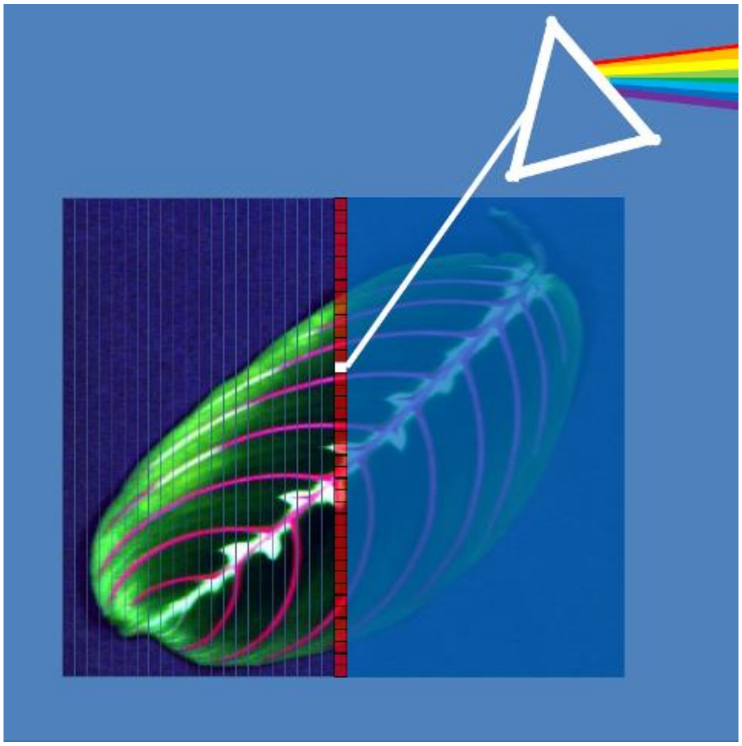

Figure 1. A hyperspectral imager spreads the light from every pixel of an image into a continuous spectrum, providing detailed information needed to accurately identify or classify objects in the scene.

Why is it useful? In contrast to a human brain, which uses only three primary colors seen by the human eye, computer vision systems can utilize many more color channels. As an example, consider the color image of two types of candy shown in Figure 2. One of the candy types is positioned in the shape of an "I." A conventional color imaging system would have great difficulty discriminating between the two similarly colored candy types (as do many humans).

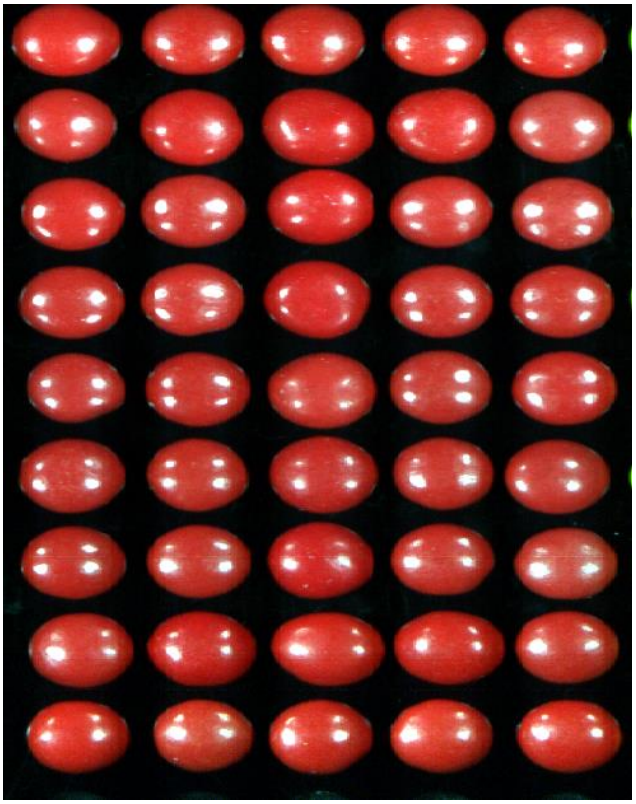

Figure 2. Color image of two types of candy. One type is organized into the shape of an "I" in the center.

Spectral curves for the two types of candy are shown in Figure 3. Notice there is considerable overlap in the curves (as one would expect with similarly colored objects), but there is also a region where there is a clear difference.

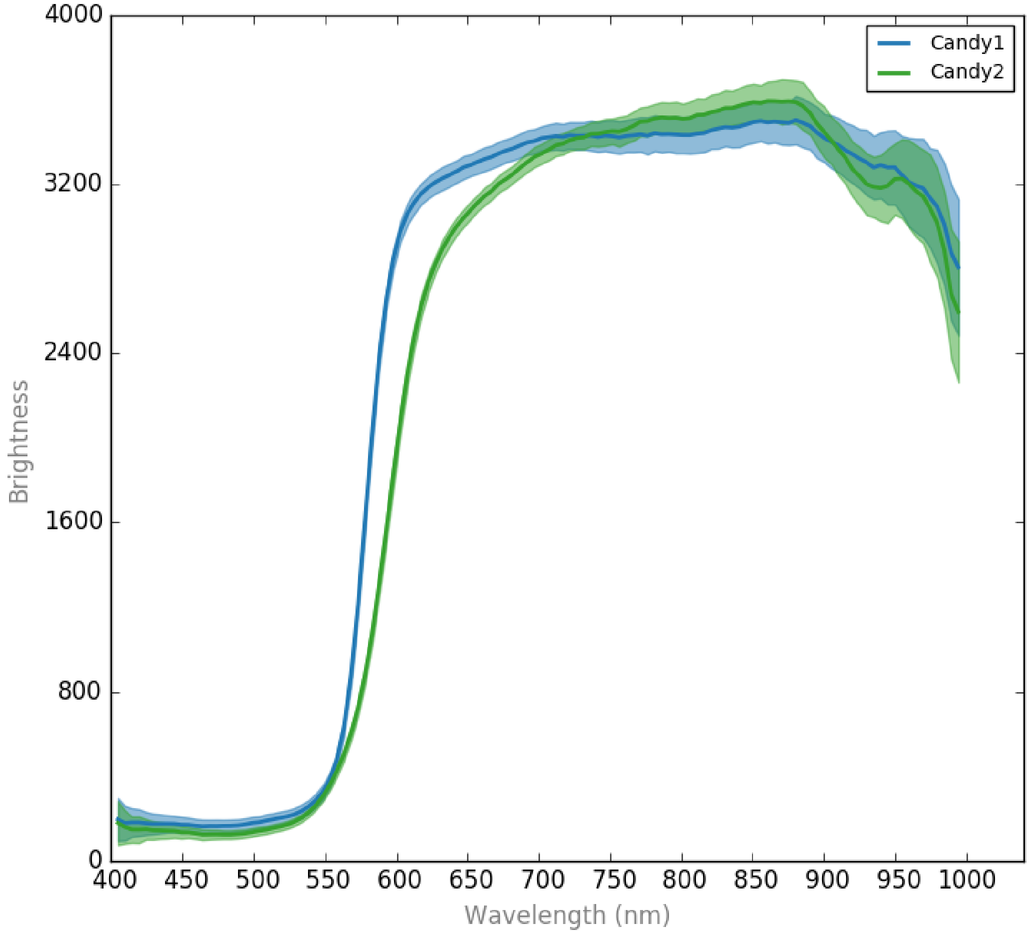

Figure 3. Spectral curves of the two candy types shown in Figure 2. The dark blue and green lines indicate the average and the shaded regions indicate the standard deviation. Notice the curves overlap for much of the spectral range, but deviate from each other between 550 nm and 600 nm in Wavelength.

Machine learning algorithms readily exploit the difference in the spectral curves shown in Figure 3 to accurately classify the candy types, which are shown in a false color classification map. The false colors match the color of the curves in Figure 3.

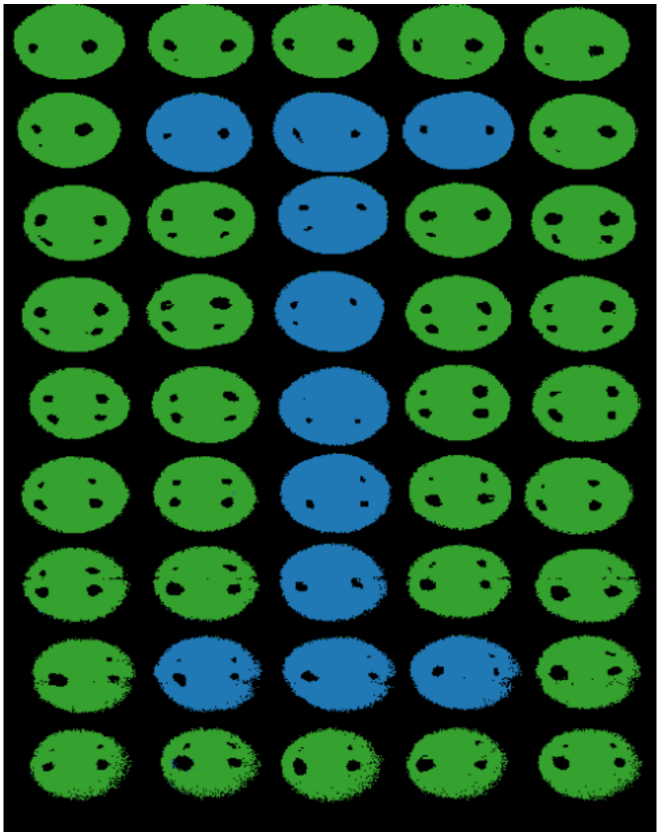

Figure 4. Classification map of the colored candies shown in Figure 2.

The candy types are accurately differentiated using hyperspectral data. The classification is performed pixel-by-pixel. Note that almost every non-glare pixel is correctly classified.

Concluding remarks: Hyperspectral imaging provided more information per pixel, which is particularly useful for distinguishing between similarly colored objects or materials. Outputs can be interfaced to robots, air-jets, labeling devices, etc. Much like the human eye, hyperspectral imaging can be applied to a wide range of applications, including quality control (lumber, textiles, paper, building materials, drugs), process control (thin films, moisture content, color), sorting (food, recyclable materials, minerals), remote sensing (ocean color, environmental monitoring, agriculture), and more. With the development of compact, low-cost, rugged hyperspectral imaging systems, the technology can be used in many environments and on platforms ranging from microscopes to airplanes.

For additional information on how hyperspectral imaging might be used to solve your problem, please contact Resonon.