Robin Myers Imaging

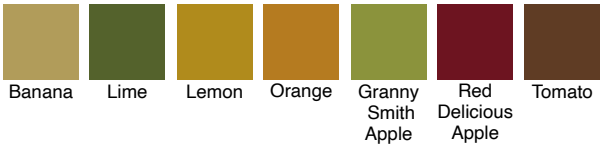
Chromaxion™

The Newsletter of Interesting Imaging Stuff

Fruit Color

Recently one of our SpectraShop™ users noticed the Spectral Library does not contain any fruit measurements. We checked, and good grief, our user was correct! (Hear that needle skipping on a record sound?)

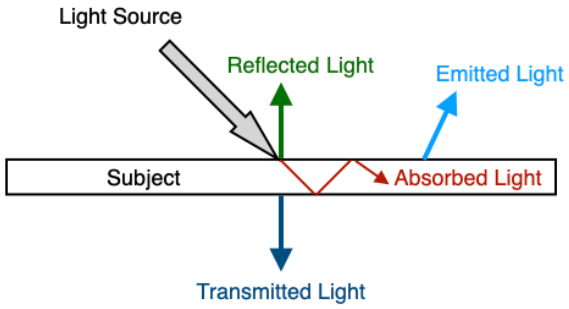
So we went to the store, bought some fruits, ones that could be purchased in single quantities. Then we got out a reflectance spectrophotometer and started measuring. Here is what we got.



Yuck! All of the measurements appeared to be from dead fruit, not from the fresh, ripe fruit we purchased. What had gone wrong?

We repeated the measurements with other spectrophotometers, getting similar results from all of them. What was wrong with our instruments?

So we decided to go back to the basics. Here is a simplified diagram of how light interacts with a reflective object.



The light from the instrument can be reflected from the subject's surface, absorbed by the subject, transmitted through the subject and emitted from the subject.

If we look at the lemon during measurement, something interesting is happening.

If all the spectrometer's illumination was being reflected to its sensor, why it there a bright yellow-orange light appearing under the instrument's measurement nose?

Looking back at the reflecting object diagram, we can make some deductions. The lemon reflects some light since we did measure something. The glow under the instrument shows light penetrating into the lemon with some of it emitting out of the lemon. The shadow beneath the lemon is the same darkness as the surrounding shadows so it does not show any light transmitting through the lemon.

The spectrophotometer is designed to measure thin materials with the majority of the light being reflected to the instrument's sensor. In our situation more of the light is being absorbed and emitted than the instrument was expecting. The result is a dark measurement.

Since we cannot change the design of the spectrophotometer, how can we measure the reflectance of fruit?

There is another type of spectrometer we might use, a telespectroradiometer. This device is designed to measure the spectrum of light sources from a distance, similar to our vision system.

Here is one such telespectroradiometer made by Photo Research.

By pointing this type of instrument at a reflecting object and having a way to calibrate the measurements to the light in the scene, a telespectroradiometer can be used to measure a subject's reflectance without being affected by the subject's light absorbance.

Calibrating the telespectroradiometer to the scene illumination can be done by making a measurement of a PTFE white spectral reference tile and dividing the subject spectra by this white reference spectrum. This white measurement records the spectrum of the illumination and its relative intensity, thus recording the light falling on our subject.

So we remeasured the fruit, this time also measuring the illumination with a white PTFE tile. The fruit measurements were divided by the white tile measurement.

Here are the results.

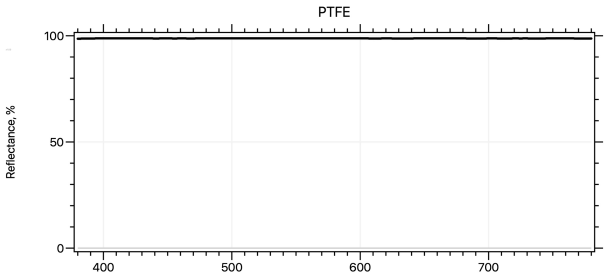
Banana | Lime | Lemon | Orange | Granny Smith Apple | Red Delicious Apple | Tomato

Notice how much brighter are the results. The fruit colors now look like the fresh fruit purchased from the store. The tomato looks like something we would like to put in a salad, instead of the garbage.

We now have a way to measure the surface reflectance of fruit.

Note:

PTFE is an acronym for polytetrafluoroethylene, known by the brand name Teflon. Powdered PTFE can be machined into tiles that have a very uniform spectral reflectance. Here is a graph of a white PTFE tile.



With a diffuse reflectance factor of 99% across the visible spectrum, PTFE is an ideal material for calibrating spectrometers.

PTFE is available commercially as Fluorilon™ from and Spectralon® reflectance standards in various tile shapes (e.g. circular and rectangular).

Colorants can be added to the PTFE to produce gray, color and wavelength reflectance standards.

Fluorilon® tiles may be obtained from Avian Technologies, aviantechnologies.com.

Spectralon® tiles are available from Labsphere, labsphere.com.

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