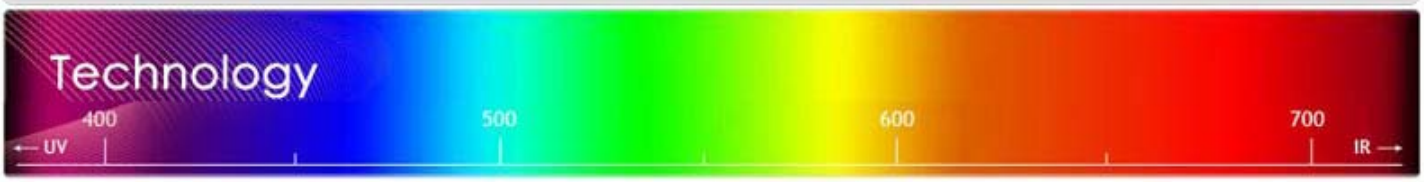

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Hubble and Machine Vision (Part II)

By Marcel Laflamme

Looking for a machine vision challenge that is worth billions of dollars?

Join the competition!

The design project will require that you capture an image of a gaseous item moving at 36,000 miles per hour. This gas cloud is extremely large and you cannot get close to it.

The project will also require you to specify the camera, framegrabber, software and lighting.

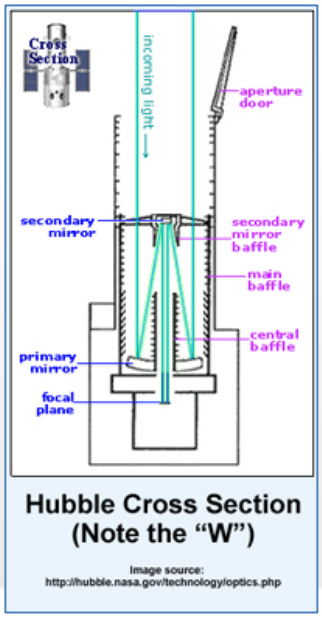
Oh, and your main competitor is the Hubble Space Telescope.

This unique and difficult machine vision application has revolutionized our worldview.

Our challenges in the more typical machine vision applications may be of a smaller scale, but in many ways Hubble has an easier task than the vision engineer. Hubble is usually looking directly at the energy source (light) and focusing that energy onto the focal plane of the camera. Hubble does not need to originate, regulate and direct energy to create the shadows and reflections needed for high contrast imaging in machine vision applications.

Machine vision applications typically gather energy (light) that is being reflected by features on the target. Is this a big difference? Yes and No. The laws of physics are the same, but the source of the energy is a third component, a light source. The vision engineer directs the interaction of the subject, the receptor (camera) *and* the energy (light source).

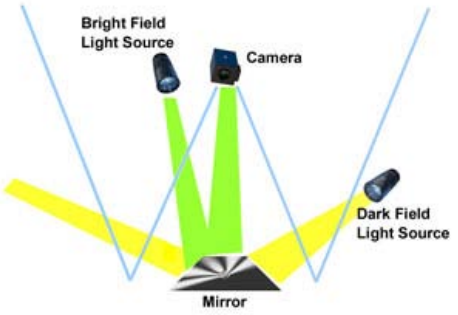
But look at the Hubble's optical assembly (left) and this machine vision application below.



Hubble Cross Section (Note the "W")

Image source: http://hubble.nasa.gov/technology/optics.php

The common feature is the "W" which is the graphical expression of a physical attribute of light energy as motion. Light travels at enormous speed (186k m/s) and has a tendency to travel in a straight line until it reaches a non transparent object. Then, as described in part 1 of this article, the laws of reflection take over. In Hubble, mirrors intentionally reflect light to the sensor in the center. In machine vision, the target reflects according to its surface features (texture, markings, etc.). The surface formation dictates the reflection angle in relation to the light source.



This brings us to the understanding of ray tracing in terms of a "W". If the target is a perfectly flat and smooth mirror surface, all light sources originating from outside the W will not be reflected back to the camera. The surface of the object will be dark to the camera, hence achieving a "darkfield" effect. All sources of light originating within the W will be reflected to the camera, hence a "brightfield" effect. In the darkfield lighting configuration, changes in the surface (textures, depressions, elevations) will change the direction of the light ray and may reflect a bright area to the camera. In a brightfield configuration, a change in the surface may reflect light away from the sensor and appear dark.

Dark field or bright field: the two most basic machine vision lighting techniques.

Next time: Part 3, Is light wavelength a factor?.

Author's note: See HUBBLESITE for more amazing images from the Hubble Space Telescope and for more fascinating Hubble facts!