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Light & Illumination Basics
Fundamentals & Training

Elementary Photons

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What is Light ?

What is light? This is a question that can be answered very simply, or be made exceedingly complicated. A simple way to answer is to say that light is a type of wave that causes objects to be visible to human eyes. The sun produces light, and that light bounces off objects and into our eyes. This makes it so that we can see things, because the brain can interpret that light and tell us what's out there. Pretty simple.

But what is light actually made of? How does it work? That deeper question is answered by physics. And it took centuries to figure out.

An important step happened in the early 20th century: we discovered that light was BOTH a particle and a wave. That might seem impossible. It might make you scratch your head, and that's certainly the way physicists felt about the idea at first. But thanks to Albert Einstein and Max Planck, we know that light can act like a particle or like a wave, depending on the circumstances. This is called **wave-particle duality**.

Polarisation Concepts & Techniques

Robert Hooke and Christian Hugens in the 17th Centruy introduced Wave Theory of Light. Light is a transverse wave, i.e. its electromagnetic and magnetic fields are disturbed at right angles relative to the direction of travel of the light waves. Or, it can be said that light waves oscillate perpendicular to their direction of travel.

Natural light, and virtually all artificial light (LEDs, incandescent lights, fluorescent lights, etc.) is unpolarized or weakly polarized. Natural light travels in any radial direction from the source of the light (Figure 1). Imagine a beam of light. Light waves oscillate 360° from every point along that beam. (An oversimplification, to illustrate the concept.)

Polarized light, on the other hand, is light in which the waves travel in only one, specific direction. Light can be polarized in nature by absorption, refraction, reflection, scattering, and birefringence (double refraction). For example, when light strikes water, it can be reflected linearly perpendicular, i.e. polarized in that specific direction, to the surface of water, which we experience as glare.

For another example, as the sun moves across the sky the angle of the sun's light striking a window will change. At some point the light will reflect off the window, or be polarized, at an angle perceived as glare.

The sky is blue because sunlight strikes the molecular structure of the atmosphere and scatters, which polarizes the light in a specific direction. As the angle of the sun relative to the atmosphere changes the polarization angle of the light also changes, and the human eye perceives color changes from dawn to midday to dusk.

Returning to the example of the sun reflecting off the surface of water and producing glare, a photographer may employ a polarization filter to remove that glare, improving the image by filtering light at the specific angle causing the glare.

Similarly, in machine vision, artificial polarization techniques help developers select or restrict the direction of the light waves that enter a camera lens and strike an image sensor. The three basic ways to artificially polarize light are linear polarization, circular polarization, and elliptical polarization, with the latter two methods serving as extensions of linear polarization and not widelu used in machine vision.

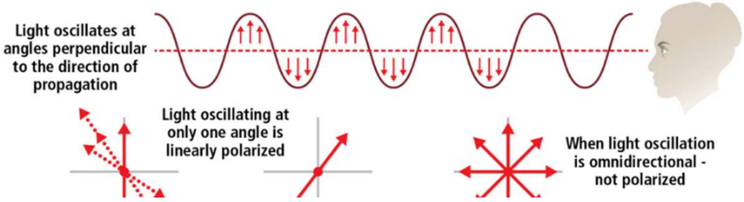

Figure A

PROTEUS electronics
Excellence reborn

Polarising Plates

Our Comet, Saturn and Ceres Series LED Lights have standard Polarising plates with pre arranged analyser. These ready for use lights are tested with differser and polariser .

DO : Use Polariser for reflections from paper, films, coated surfaces, Shrink wrap, Plastic packaging, Blister packing.

DON'T : Use for mirror surfaces

DO : Setup Aperture to get Optimum brightness. Polarisers will reduce the light received on the camera sensor x2.

DO : Adjust the analyser by rotating to NULLIFY glare for optimum image.

BE AWARE : Some plastic films will show large DARK Areas. This is a inherent property of plastic. Work around this by rotating the setup.

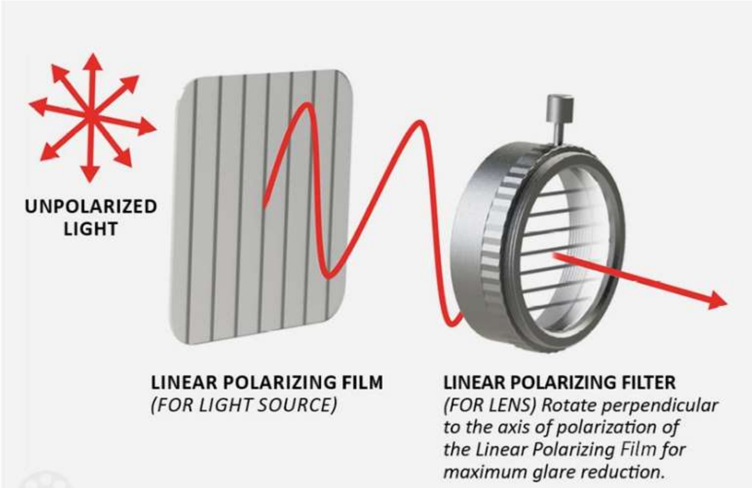

Figure B : Polarisation of light

Dichroic, thin-film, and wire-grid polarizers represent the most common components used in machine vision to linearly polarize light. Wire-grid polarizers specifically can withstand the power levels of lasers, which can be useful in factory and scientific environments.

Polarization filters function by selecting or restricting light waves traveling in a single plane. The orientation of the filter determines the orientation of the light waves that can pass through the filter, thereby selecting one set of light waves to advance and preventing others from continuing (Figure B).

Use of multiple filters, each of which prevent the passage of light waves at different orientations, allows finer attenuation of light. A filter only allowing vertical light to pass, followed by a filter only allowing horizontal light to pass, would act together to block most of the light waves passing through the filter .

Applications and implementation

Common polarization techniques in machine vision include inspection of glass and highly reflective materials. Raw and machined metal have grain at a microscopic level that can lead to linear polarization, making the use of a polarization filter useful. Plastic and glass, automotive, packaged materials, semiconductor, and LCD inspection applications commonly make use of polarization filters.

The proper way to employ polarization in an inspection environment typically involves polarizing both the light source and the reflected light (Figure 3) with a polarizer placed at the source of the light, at an angle that benefits the application, and a second polarizer placed at the same or a complementary angle, onto the lens of the camera conducting the inspection.

Even if the light projected onto an object is polarized in order to limit the potential number of reflective polarization angles, the reflective properties of the object may still create unwanted polarization when the light reflects off the object. Employing two filters allows for finer control of the light angles that enter the camera, ensuring the desired crispness of the image.

Placing a polarizer only over the camera lens, and thus only polarizing the light reflecting off the object to be inspected, may sometimes be an effective technique but far more often not. To demonstrate the point, consider the example of photography.

The polarizers used by photographers rotate, to allow the photographer to attune the polarizer to the precise angle at which the light is being polarized by the surface of the subject in the scene. The photographer tunes the angle of polarization as needed for different scenes, not a practical technique for automated imaging in machine vision.

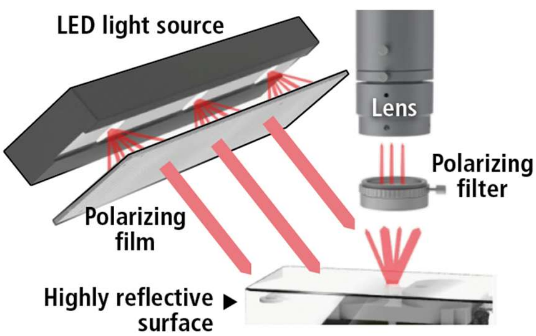

Figure C : Typical System Setup