INFRARED THERMAL IMAGING DEFINITIONS AND TERMS

Following is a collection of terms and words used in the thermal imaging market that you should know and understand:

ABSOLUTE TEMPERATURE SCALE - Thermodynamic temperature scale, named for Lord Kelvin, in which temperatures are given in Kelvin's(k). The absolute zero of temperature is zero K, or -273.16□C or -459.7□F. The size of the Kelvin unit (degree) is the same as that of the Celsius degree.

ABSORBTANCE - Ratio of the absorbed radiant or luminous flux to the incident flux.

ABSORPTION - The loss of light as it passes through a material, generally due to its conversion to other energy forms (typically heat).

ABSORPTION BAND - A region of the spectrum in which the absorption coefficient reaches a maximum.

ABSORPTION COEFFICIENT - An indicator of a material's internal absorptance. If the unit transmission of the material is t, the absorption coefficient (a) is:

a= loget

ACTIVE ELEMENT - Also known as responsive element. that part of a detector upon which energy is projected and which, when radiation falls on it, undergoes a physical change that results in an electrical signal.

ACTIVE INFRARED SYSTEM - A system in which the object is illuminated by an infrared light source making it visible to the infrared viewer. Early versions of the sniper scope were active infrared systems.

ACTIVE LAYER - That layer in a semiconductor injection laser or light-emitting diode that provides optical gain.

AMBIENT LIGHT - Light present in the environment around a detecting or interpreting device, especially a machine vision system, and generated from outside sources. Such light must be treated as noise by the vision system.

AMBIENT NOISE - The all-encompassing noise associated with a given environment, usual being a composite of a number of sources, far and near.

AMBIENT TEMPERATURE - The prevailing temperature in the immediate vicinity of the object; the temperature of its environment.

ANTIREFLECTION COATING - A thin layer of material applied to a lens surface to reduce the amount of reflected energy. Ideally the index of refraction of that material should be equal to the square root of the product of the indices of the material on either side of the coating, while the ideal thickness for a single layer coating is one quarter of the wavelength at which reflectance is to be minimized.

APERTURE - An opening or hole through which radiation or matter must pass.

ARRAY - Multiples of light-sensitive or infrared sensitive elements in cameras, detector or scanning devices.

BACKGROUND LUMINANCE - The intensity of the light in the scene behind an object being viewed.

BLOB - A group of adjacent pixels in an image representing the same value, as all black in a binary image.

BLOOMING - the loss of focus of a camera sensor because of excessive brightness, characterized by the enlargement of spot size and halation on a cathode ray tube.

BOLOMETER - a very sensitive thermometric instrument used for the detection and measurement of radiant energy. Its essential component is a short narrow strip covered with a dead black absorbing coating and mounted at the lower end of a long cylindrical tube having a stop across it to exclude unwanted radiation. The electrical resistance of the strip changes with the changes in temperature that arise from absorbing varying amounts of radiant energy.

CHARGED COUPLED DEVICE (CCD) - A self-scanning semiconductor imaging device that utilizes MOS (Metal Oxide Semiconductor) technology, surface storage and information transfer. It consists basically of a metal insulator semiconductor (MIS) capacitor, majority carriers being attracted to the semiconductor insulator interface when a negative voltage is applied to the metal. Reversal of the voltage polarity creates a region depleted of majority carriers, an empty potential well. Minority carrier charge representing information accumulates in the well, partially filling it. Information is transferred from one well to another.

CHARGE INJECTION DEVICE (CID) - A solid state imaging device utilizing an image sensor composed of a two dimensional array of coupled MOS (Metal oxide semiconductor) charge storage capacitors and designed to convert near-infrared energy. to electrical signals, providing broad gray shade or tonal rendition.

COOLED INFRARED DETECTOR - An infrared detector that achieves a specified sensitivity through the application of certain cryogenic temperatures.

FOCAL PLANE - A plane (through the focal point) at right angles to the principal axis of a lens or mirror: that surface on which the best image is formed.

FOCAL PLANE ARRAY - A linear or two-dimensional matrix of individual

detector elements, typically used at the focus of an imaging system.

FORWARD LOOKING INFRARED (FLIR) - A night vision device that uses one or more infrared transducers to scan a scene in the 3-5 micron or 8-12 micron wavelengths, convert the infrared radiation to electronic data and present the resulting image on a TV like screen. The term originally referred to air borne systems but now is used for any real time thermal imaging systems.

FRAME FREQUENCY - The number of times per second that the frame of an image is completely scanned.

FRAME GRABBER - Image processing peripheral that samples, digitizes and stores a camera frame in computer memory.

HISTOGRAM - A graphic representation of a distribution function such as frequency by means of rectangles whose widths represent the intervals into which the observed values range is divided and whose heights represent the number of observations occurring in each interval.

HYBRID FOCAL PLANE ARRAY - A device where each pixel is the detector array is mated with a preamplifier in a single silicon chip, providing sensing and signal processing capabilities.

IMAGE SUBTRACTION - A method used to compare two pictures of the same subject taken at different points in time.

INFRARED PHOTOCONDUCTOR - A photoconductor that demonstrates increase conductivity during its exposure to infrared radiation.

INFRARED SCANNER - An optical system used to collect infrared energy from a scene using scanning optics with a point or line detector, as compared to a fixed optical system with a full two-dimensional detector array.

MACHINE VISION - Interpretation of an image of an object or scene through the use of optical non-contact sensing mechanisms for the purpose of obtaining information and/or controlling machines or processes.

NIGHT VISION DEVICE - A device that uses low-level visible radiation or infrared radiation to produce a visual image of a night scenes. These devices may rely on the amplification of existing visible light by photomultiplier tubes or infrared recording.

NOISE EQUIVALENT DELTA TEMPERATURE - In a thermal imaging system, the change in temperature that yields a signal-to- noise ration of unity.

PIXEL - Contraction of “picture element”. A small element of a scene, often the smallest resolvable area, in which an average brightness value is determined and use to represent that portion of the scene. Pixels are arranged in a rectangular array to form a complete image.

PLATINUM SILICIDE - A semiconductor material used in photo detectors, sensitive in the infrared up to 5 microns.

PYROELECTRIC INFRARED DETECTOR - Unlike the thermocouple or bolometer, the pyroelectric infrared detector is a current source with an output proportional to the rate of change of its temperature. Capable of extremely rapid response and insensitivity to DC effects, it is widely used in radiometric systems from industrial temperature measuring systems to environmental satellite instruments and in the analysis of infrared lasers as well.

THERMOELECTRIC COOLING - A refrigeration method based on the Peltier effect. When an electric current passes through a thermocouple of two dissimilar metals joined in tow places, heat is absorbed at the cold junction and dissipated at the hot junction. The cold junction can be mounted in the chamber to be cooled.

Area of Interest (AOI)

Area of an image where some calculation occurs such as calculating the Average, maximum, or minimum temperature. Also called a region of interest.

Blob Analysis

Identification of segmented objects in an image based on their geometric features (ie area, length, number of holes).

Camera link

Camera Link is defined as a camera-to-frame-grabber cable specification. It defines a single connector for both the frame grabber and camera end, and ensures that all Camera Link products are interchangeable with one another.

CCD

Today's FPA detectors have two basic types of readouts for taking each detector's signal and getting it to the camera's signal. These are known as CCD (Charge Coupled Device) and CMOS. The CCD Detector operates in a mode where the signal from each detector is determined by transferring its electrons from one detector to the next down the row until it reaches the end column where it is read out. You can think of this by envisioning a bucket brigade where the contents of a bucket at the beginning of a line is transferred to the end of the line by passing it from bucket to bucket.

CCD detectors are widely used in imaging applications since the losses encountered by Charge Couple Transfer Loss Phenomenon and blooming are typically not relevant in non-measurement scenarios. When a CCD detector is utilized in a measurement IR FPA camera, compensations must be done to reduce errors caused by this issue.

CMOS Detector

A CMOS detector has a readout that is made up of a series of MOSFET (Metal Oxide Semiconductor Field Effect Transistors) that provide Direct Access to the signal from each detector. In a CMOS detector, the signal from each detector is read out column by column and row by row, until each detector has been addressed individually. The benefit to this technique is that the exact value for each detector is transmitted to the signal processor for measurement.

CMOS circuits are ideal for low power applications. Power dissipation in a detector readout circuit is critical because it must be cooled with the detector to approximately -200°C. Even with a highly efficient cooler, each milliWatt of power dissipated by the readout requires about 25 MWatts of battery power for cooling. Optimum battery life is achieved by the use of a CMOS multiplexer detector readout and high efficiency rotary Stirling cooler.

CMOS detectors are generally thought to provide better accuracy for measurements as a result of their direct access readout capability. Predictive/Preventative (P/PM) users who require high measurement accuracy and long battery life can benefit from this technology.

Digital Camera

The newest generation of video cameras transform visual information into pixels, and then translate each pixel's level of light into a number in the camera.

F-number or f-stop –

The ratio of the focal length to the lens aperture (the optical diameter of the lens that lets incoming energy impinge the FPA). The smaller the f- number, the larger the lens diameter and brighter the image and narrower the depth-of-field.

Firewire

IEEE 1394 is a standard defining a high speed serial bus. This bus is also named FireWire by Apple or i.Link by Sony. All these names refer to the same thing, but the neutral term IEEE1394 (or just 1394) is used on these web pages and in the sources.

What exactly is IEEE 1394? It is a serial bus similar in principle to USB, but runs at speeds of up to 400 Mbit/s and is not centered around a PC (i.e. there may be none or multiple PCs on the same bus). It has a mode of transmission which guarantees bandwidth which makes it ideal for digital video cameras and similar devices.

Field-of-view

The 2D area which can be seen through the optical imaging system. (FOV)

Frame Grabber

A device that interfaces with a camera and, on command, samples the video, converts the sample to a digital value and stores that number in a computer's memory.

FPA (Focal Plane Array)

The first, and most widely used term to come with this new technology is the term Focal Plane Array, which describes the technology itself. A Focal Plane Array (FPA) detector is considered to be any detector which has more than one row of detectors and one line of detectors together. For example, the smallest conceivable FPA detector would have a configuration of 2 X 2 detectors (two rows and two columns). This configuration is basically described by the term Array. The term Focal Plane refers actually to the location of the detector array in the optical path. The Focal Plane of an optical system is a point at which the image is focused. Thus, in a FPA system, you have an array of detectors at a point where the image is focused on them. Most typical IR FPA systems available today have an array of 256 X 256 detectors or more (256 columns and 256 rows).

FPA detectors bring high resolution IR imaging capabilities into the P/PM users' hands. By having an array of detectors "staring" at the scene rather than a single detector being scanned across the scene, IR cameras have become much smaller, lighter and more power efficient. Today's modern IR FPA systems have the portability of video palmcorders and the imaging quality of black and white TV cameras.

GUI

An acronym for Graphical User Interface. Pronounced "gooie." A Windows based user interface screen or series of screens allowing the user to point-and-click to select icons rather than typing commands.

Histogram

A graphical representation of the frequency of occurrence of each intensity or range of intensities (gray levels) of pixels in an image. The height represents the number of observations occurring in each interval.

Line Scan Camera

A solid state video camera consisting of a single row of pixels. Also called a linear array camera.

Machine Vision

The use of devices for optical non-contact sensing to automatically receive and interpret an image of a real scene, in order to obtain information and/or control machines or processes.

Morphology

Image algebra group of mathematical operations based on manipulation and recognition of shapes. Also called mathematical morphology. Operations may be performed on either binary or gray scale images. Parallel processors are useful to implement.

Microbolometer

Microbolometer cameras are different from cameras that detect individual photons through photovoltaic or photoconductive means. In a microbolometer camera, individual pixels receive different amounts of thermal radiation from the scene and heat up different amounts with respect to the bolometer array substrate. The part of each bolometer that heats up is thermally isolated from the substrate so that a very small amount of input IR power results in a measurable change in the bolometer's temperature. By selecting the thermal conductance to the substrate and also selecting the thermal mass (heat capacity) of the thermally isolate bolometer, the bolometer's thermal time constant is determined. The array substrate is held at a very stable and uniform temperature so that the bolometer heats up to a specific temperature for a specific amount of input IR radiation from the scene. The amount of heating of each pixel (and thus the intensity of the IR scene) is determined by passing a known current or applying a voltage through a resistive element in the thermally isolated section of the bolometer. The resistive element is made from a material that changes resistance significantly with temperature. If a known voltage is applied across the bolometer's resistor for a short time, the current generated will be related to the resistance value, which in turn is related to the temperature of the bolometer, which is a direct measure of the incident IR radiation.

Nonuniformity Correction

One of the less desirable characteristics of modern FPA detectors is their relative nonuniformity from detector to detector. This results from variations in the manufacturing process and the detector material itself. The fact remains that all FPA detectors are fairly nonuniform in their response to temperature when they are built.

To correct for this, virtually all FPA cameras have some type of nonuniformity correction built into the camera. Methods for correcting this problem vary greatly from manufacturer to manufacturer. The most simple approach is when a lens cap is placed on the camera and a "NUC" button is depressed and the camera corrects for uniformity based on the temperature of the lens cap. Other systems have a uniform temperature "paddle" within the camera which is inserted in the optical path periodically to correct the detector. Some systems have permanent multi-point nonuniformity correction, where the detector is corrected at a variety of scene temperatures for each range and then the data is stored within the unit, so the user never has to perform a nonuniformity correction in the field. This appears to be the best approach since it requires no user intervention and also provides for nonuniformity correction at several temperatures and not just at the lens cap temperature as with other approaches.

Nonuniformity correction is an important parameter for the P/PM user to consider given that it needs to be done each time you change ranges, lenses, or when the camera operating temperature varies. Systems that do this automatically will prove

to be the easiest to use in the field. The best nonuniformity correction will be accomplished at a temperature as close to the object temperature as possible. For example, when looking inside a furnace at 1300°F, a nonuniformity correction on the lens cap at 75°F is of little value. The best approach in this case, is to have a nonuniformity correction point that would "equalize" the array at a temperature around 1300°F. Today, this can only be accomplished with systems that feature permanent multi-point nonuniformity correction.

OLE

Object Linking and Embedding A set of system services that provides a means for applications to interact and interoperate. Based on the underlying Component Object Model, OLE is object-enabling system software. Through OLE Automation, an application can dynamically identify and use the services of other applications, to build powerful solutions using packaged software.

OLE also makes it possible to create compound documents consisting of multiple sources of information from different applications.

RS-170

The Electronic Industries Association (EIA) standard governing monochrome television studio electrical signals. The broadcast standard of 30 complete images per second