Qualitative Vs Quantitative Infrared

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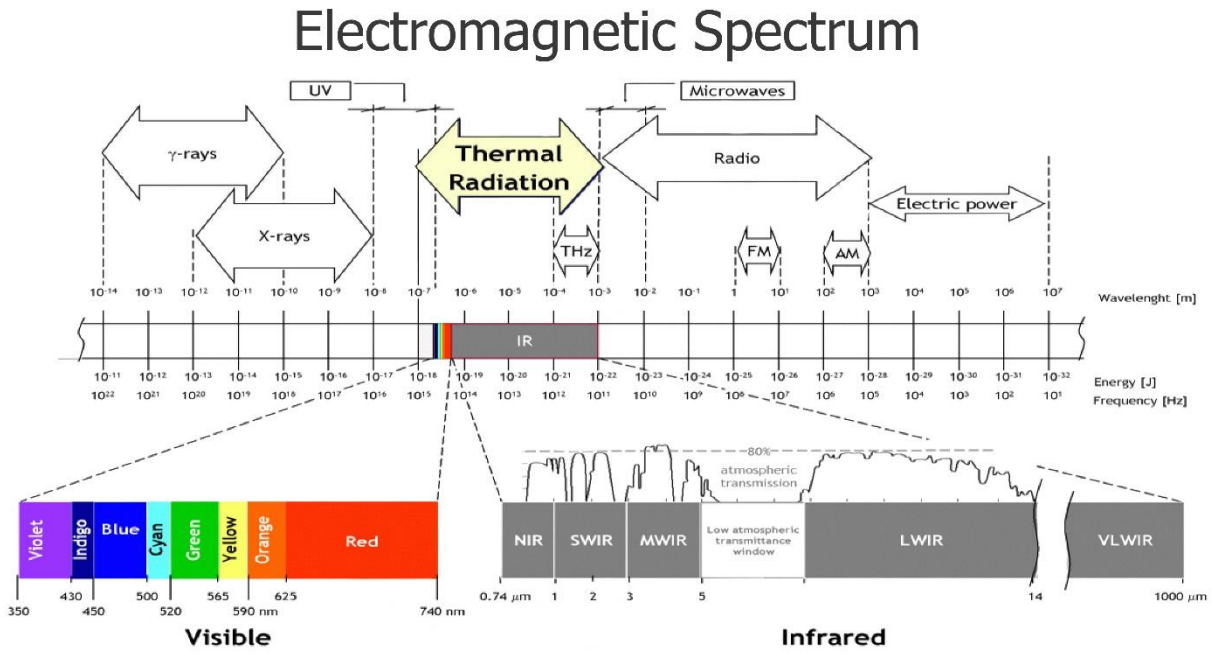
Abstract

With the introduction of Unmanned Aerial Vehicles into the national airspace, the ability to remotely acquire data, from the infrared spectrum, has become increasingly relevant. As many industries quickly move to add remote aerial data acquisition capabilities, it is important to understand the differences between qualitative and quantitative infrared.

Background

To truly understand the difference, one must have a general understanding of the electromagnetic spectrum. Visible cameras, just like our eyes, provide an interpretation of the electromagnetic spectrum from a very narrow vantage point. This vantage point is less than .001% of the entire spectrum, yet it represents everything we visually understand about the world around us.



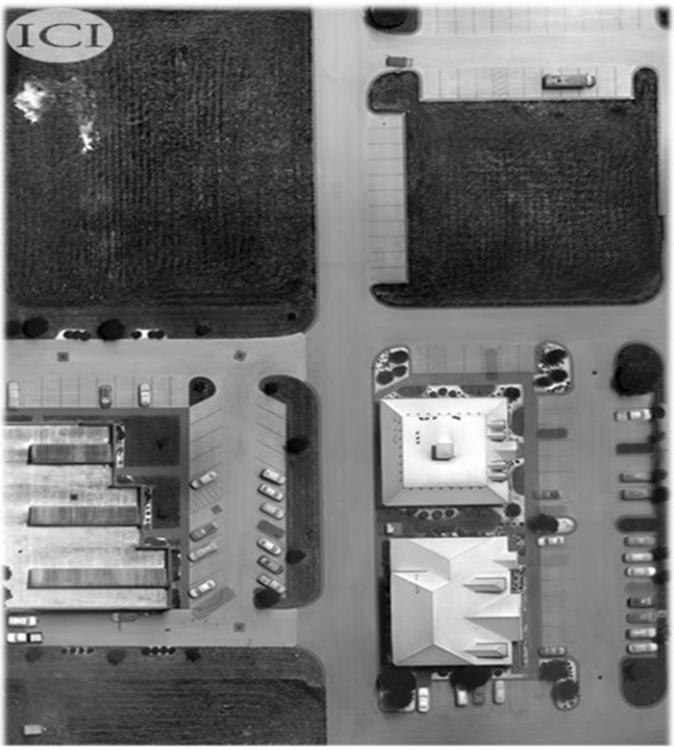
There is another subset of the electromagnetic spectrum, invisible to you and me, where "light" i.e. "radiation" i.e. "energy", does some very special things. It is known as the infrared spectrum. The infrared spectrum picks up where our sight ends and continues out more than a thousand times further than that of the visible spectrum. Just like the visible spectrum has divisions of color, the infrared spectrum is divided into subsections. These divisions include Near Infrared (NIR), Short Wave Infrared (SWIR), Mid-Wave Infrared (MWIR), Long Wave Infrared (LWIR) and Very Long Wave Infrared (VLWIR).

ICI 9640P Series
(LWIR Camera with USB Interface)

Many sensors exist that allow us to "see" in the infrared spectrum. In certain areas of this spectrum, radiation emitted from objects will allow us to "see" temperature. In other areas of the spectrum, water absorbs energy better, allowing us to "see" moisture content. Certain gasses or compounds may reflect and/or absorb energy, in areas of this spectrum, giving us the ability to "see" that they exist in a scene. However, in order to "see" anything with our eyes, it will always be a limited representation based on the visible spectrum.

Qualitative Vs Quantitative

This is where the terms qualitative and quantitative arrive to describe the difference between the visible representation of the energy and the actual sensor's interpretation of the energy. Seeing an image from an infrared sensor, where white is hot and black is cold, can give us an indication as to whether an object is cooler or warmer than another object. But such an image would not provide the actual temperatures. We refer to this as "Qualitative Infrared". Alternatively, if we processed the data from each pixel of the sensor, as opposed to creating just a visible representation, we could create an array of data where every pixel becomes an actual temperature value. This is what we refer to as "Quantitative Infrared".

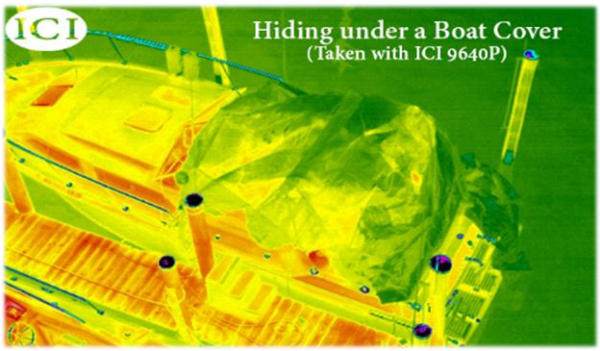


Aerial Infrared Mosaic
(created from more than 100 individual images taken with an ICI 9640)

When we create a visible representation of what an IR sensor is perceiving, we actually throw away a good majority of the data. The RGB (Red-Green-Blue) standard, by which we build a visible representation, allows for us to create a high quality 24-bit picture or video. Yet, due to the fact that IR is scaled linearly and only has a single channel, it can only utilize 8-bits of that visible imagery method. All gray scale imagery will have equal 8-bit values across the RGB scale. In other words, there can only be 256 shades of gray. Thus, there can only be 256 divisions of temperature. Today, most IR sensors are exponentially more sensitive, offering up to 16-bits of resolution or 65,536 divisions of temperature.

Limitations

Knowing this, we now understand that having an infrared sensor with an "analog video" output will only provide the 8-bit version of what the sensor is perceiving. While this might suffice for some basic aerial search and rescue applications, it will, in no way, provide the quantitative data one might require, for instance, to make an educated decision about the best point of entry into a building that is on fire. Or determine temperature deltas between healthy and stressed vegetation. Likewise, building mosaics from multiple qualitative IR images can be very challenging. Without the ability to fix the Level and Span, the temperature scale will not remain consistent across all images.



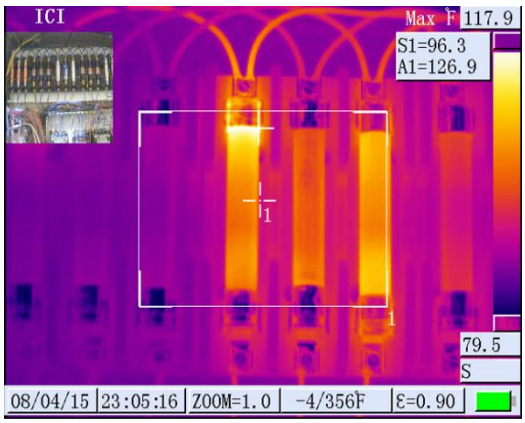
Just about every IR sensor, in the market today, provides a visible representation as an output. And some provide a digital interface to obtain the raw data as well. But many times, this interface is based on a protocol primarily used in the military and scientific community known as Camera Link. This protocol is a high speed interface that requires a special communication card to collect and interpret raw data streams from high end cameras. While very effective at collecting data, it requires a desktop computer or specially equipped laptop, external power sources for the computer and camera alike, and large bulky cables having more than 20 internal wires with large connectors. When it comes to providing light weight aerial data collection methods for the sUAS (small Unmanned Aerial Systems) market, Camera Link is in no way a viable solution. And it is certainly not applicable in the civilian market, where a single point connectivity system, providing power and communication, already exists...Universal Serial Bus (USB).

Flir Tau 2
(Analog Composite or Camera Link)

Solution

Thermography is the answer. More precisely…Remote Aerial Thermography.

Many highly skilled Thermographers inspect and quantify risk in just about every industry including electrical, industrial, petrochemical and even medical. Using high end, hand-held, infrared cameras, a good Thermographer can locate and assess the failure risk of a given system. Or, they might provide a lifesaving diagnosis. Because they incorporate an embedded computer, these thermography cameras have the clear advantage of providing both the qualitative imagery and quantitative data to the Thermographer, via their GUI (Graphical User Interface).



Sample Image showing Qualitative IR Imagery and Quantitative IR Data

Today, many single board computers exist such as Raspberry Pi, Gumstix, Via Embedded, Intel's Galileo, Odroid, along with countless others. These light weight and powerful computers are an easy solution for the embedded management of USB based sensors. They typically offer more than one USB interface, composite and/or HDMI video outputs, and a GPIO (General Purpose Input Output). The GPIO can be programmed to facilitate external interfaces such as CAN bus, S.Bus and PWM/PPM just to name a few. An embedded system, such as this, would not only provide the qualitative visible feedback from any of the on-board sensors, but, it would also store the raw quantitative data simultaneously to any number of removable media options. Additionally, it would provide the required interface between the Thermographer and the on-board sensors, allowing the end user to control and interact with the system.

Pilot Inspection on a Petrochemical Ground Flare
(Taken from a UAV with an ICI 9640P via the Sensor Control Module)

Infrared Cameras Inc. is proud to announce a product line with this quantitative data acquisition model in mind. The all new ICI "**Sensor Control Module"** serves as an embedded system specifically designed to interface with many remote and/or aerial systems. A full line of USB sensors including Visible, NIR, SWIR, MWIR and LWIR are available. What's even better, multiple sensors can be managed, simultaneously, by the Sensor Control Module, making remote aerial thermography and multi-spectral data acquisition a real and viable possibility.

ICI Sensor Control Module

INTERFACE OPTIONS

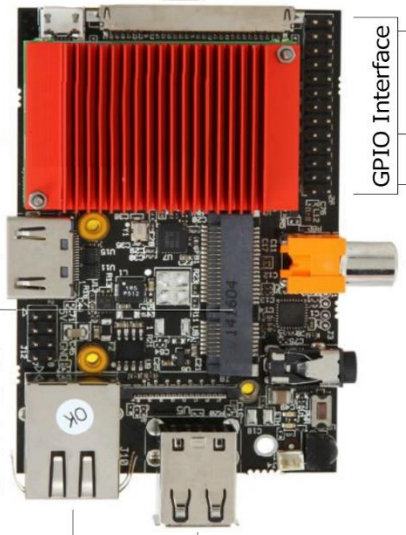
Amimon Connex

DJI Lightbridge

HDMI Video Output

PWR

Data Storage



GPIO Interface

S.Bus Sensor Control

TTL/PWM

CAN Bus

S.Bus RX

Capture *
Sensor Select *
Sensor Mode *
Mode Toggle *
Level High/Exposure *
Level Low/Gain *
Zoom *

DJI Lightbridge

Amimon Connex

MSATA Optional Interface Cards

WiFi

GPS

Analog Composite Video Output

GPS Data Acquisition *

Autonomous Capture *

DJI Naza
DJI A2
DJI Wookong

2.4Mhz/5.8Ghz
Video Transmitter

PC

Optional Wired Interface
(10/100/1000 Megabit Ethernet)

USB Sensor Options (Capable of Simultaneously Managing 3 Sensors)

Sony QX10	**Sony QX30**	**ICI Vis/NIR**	**ICI SWIR**	**ICI MWIR**	**Flir Tau**	**ICI 9320**	**ICI 9640**
18mp/10X	24mp/30X	5mp	320/640	320/640	336/640	320X240	640X480
.35 to .75um	.35 to .75um	.35 to .85um	.9 to 1.7um	2 to 5um	7 to 14um	7 to 14um	7 to 14um
(Requires WiFi Module)	(Requires WiFi Module)				(Requires ICI USB adapter)		