![sightlogix making outdoor video…smarter]

A New Perspective on Thermal Imaging

Thermal security cameras have been known for nighttime applications under low or zero lighting conditions. When conditions are ideal, thermal cameras allow a person to "see" what the eye cannot, even in complete darkness.

However, outdoor conditions are rarely ideal:

- Daytime thermal images often appear white and blurry, lacking scene details

- Environmental conditions of rain, heat and humidity degrade image quality

- Thermal cameras may miss intruders due to outdoor conditions, even at night

As a result, many thermal cameras are unable to provide important details and situational context for making quick and effective security decisions.

The key for the successful use of outdoor security thermal cameras is to provide a good clear image day and night. This is achieved with image processing that adapts to dynamic outdoor conditions. As shown in Figure 1, when proper technology is applied, necessary daytime details can be achieved without augmentation from visible cameras, returning the value of thermal imaging for outdoor twenty-four hour use.

Market-leading Thermal Camera   Image-enhanced Thermal Camera
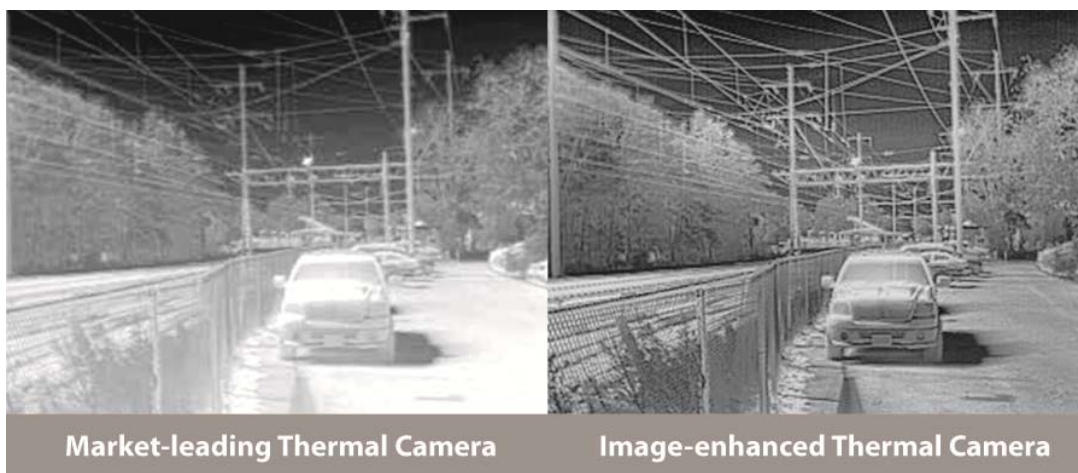
Figure 1: Comparison of Thermal Images Without and With Image Processing

Understanding How Thermal Cameras Work

Our eyes work by seeing contrast between objects that are illuminated by either the sun or another form of light. Thermal cameras operate by sensing heat energy from objects, referred to as emissivity.

- All objects – living or not – have an emissivity and temperature that thermal cameras use to detect the image

- The primary benefit to sensing heat is that heat is always available, day or night

- Thermal cameras can operate at all times, even in complete darkness

Because thermal cameras "see" heat rather than reflected light, thermal images look very different than what's seen by a visible camera or the eye.

In order to present heat in a format for human vision, thermal cameras convert the temperature of objects into shades of gray which are darker or lighter than the background.

- On a cold day a person stands out as lighter because they are hotter than the background

- On a hot day a person stands out as darker because they are cooler than the background

For these reasons, thermal cameras have become a good choice for "seeing in the dark" because at night background objects tend to be cooler than a person at 98.6 degrees. Under ideal conditions, people are well emphasized at night because they appear brighter than the background and stand out, even in zero light.

However, outdoor security conditions are rarely "ideal". Problems occur when the environment brings background temperatures close to the temperature of objects which represent security concern, such as a person entering an unauthorized area. When background temperatures closely match the heat of a person, the intruder can blend into the background and become concealed, even when they are close to the camera itself, while the overall image appears blurry and poorly defined.

When people and other objects are thermally concealed during the day they are still visible to the eye, which is why thermal cameras are often paired with visible cameras, driving up security costs. Recent advancements in the sensitivity of thermal imagers, combined with sophisticated image processing to present clearer images regardless of conditions, eliminates the need for additional visible cameras.

Environmental Issues that Conceal Targets

Most thermal cameras have difficulty presenting good outdoor images due to the impact of the dynamic environment. Even nighttime applications create difficulties for thermal cameras when conditions reduce the temperature contrast between objects in the scene to conceal targets.

- Rain and humidity will bring objects in the scene to a similar temperature that match the background
- A background that is close in temperature to a person will camouflage an intruder

Figure 2, taken by a market-leading thermal camera during a heavy storm at night, shows how moisture in the air from rain and humidity can conceal a human target.

Figure 2: Rain and Humidity Conceal Targets

In this example, rain has cooled the scene until there is very little temperature differentiation between the person and the background. Under these conditions, most thermal cameras are unable to distinguish between objects in the foreground and the background due to the lack of temperature variation. The result is a blurry image that conceals the person walking, leading to a gap in security.

This is similar to what is visually experienced when someone wearing white clothes walks in front of a white building. When there is little visible contrast between the edges of a person and background, the person looks blurry or even "disappears." Likewise, when environmental conditions create a uniform temperature across the scene, the absence of contrast will cause thermal cameras to miss intrusions entirely.

Thermal Loading and White-Out

During the day darker objects absorb the sun's energy and heat up, an effect known as Thermal Loading. When objects in the scene become uniformly hot in some areas, many cameras have difficulty mapping the wide range of temperature differences into a useful image. Thermal cameras display hotter objects as a lighter shades of gray, resulting in areas that look "whited out" and undefined.

Figure 3 shows a market-leading thermal camera during the day which cannot effectively compensate for white-out. Details such as the fence fabric, power lines, vehicle detail and other objects have been concealed by lack of temperature difference between the infrastructure and the background.

Figure 3: White-Out Causes Blurry Images

White-out is not limited to bright summer days. In winter, the sun's energy will raise the temperature of objects such as pavement and buildings to be much higher than the ambient temperature. The temperature of the background can often exceed that of a person, creating situations where a person cannot be seen even on cold days.

Thermal Crossover Conceals Targets

Thermal crossover occurs when objects such as buildings and parking lots that were heated during the daytime start to cool after sunset. At some point, they will "crossover" 98.6 degrees, becoming almost indentical to the temperature of a person.

When targets are very close in temperature to the background, they are displayed on the monitor as a similar shade of gray. The eye cannot distinguish between very close grayscales, camoflaging the intruder against the background.

Thermal Crossover, which affects thermal cameras every day shortly after sunset in all parts of the world, can also occur during the day in certain situations. Figure 4 shows an image from a market-leading camera on a warm afternoon. A person has walked along hot pavement towards an area which has been shielded from the sun by an overhanging canopy. The area under the canopy closely matches the temperature of the person. As a result, the person blends into the background, become almost completely invisible.

Figure 4: Person Camouflaged by Thermal Crossover

Thermal cameras which are not designed to adapt to thermal crossover will leave blind spots in coverage where intruders will go undetected.

Long Range Issues

Energy from objects that are further in distance sends less energy to the camera than objects that are closer to the camera. The air itself further decreases the energy as it travels through the atmosphere, which worsens over longer distances. Many of the finer details about distant objects will be lost, resulting in backgrounds that lack clarity and appear out of focus.

Lack of image clarity can reduce security effectiveness. Scene details such as towers, buildings or other objects provide important context about where a camera is viewing.

- It becomes difficult or impossible for operators to make good security decisions without context.

- Clear images can help determine a real

Figure 5: Distant Objects Lack Detail

threat from one that can be safely dismissed.

- Security personnel who have to view blurry, undefined video even on a single monitor can become fatigued and confused by images that are not as intuitive as they would be with daylight cameras.

The Processing Demands of Image Enhancement

Thermal imagery is very rich in data, sensing temperature variations down to $1/20^{th}$ of degree. These fine differences are represented by over 16,000 shades of gray.

- 16,000 shades of gray far exceed the human eye's capacity of about 256 grayscales.

- The camera must reorganize these thousands of grayscales into a compressed image of about 256 shades, consistent with what the eye can see.

Figure 6 illustrates the eye's difficulty distinguishing between close levels of gray. The top row shows six levels of gray which the eye can see. The bottom row shows sixteen shades of gray where it is increasingly difficult to distinguish where the scales transition from one block to the next. Consider a thermal imager has 16,000 shades of gray, over 1000 times more than show in the lower bar graph.

Four Shades of Gray

Sixteen Shades of Gray
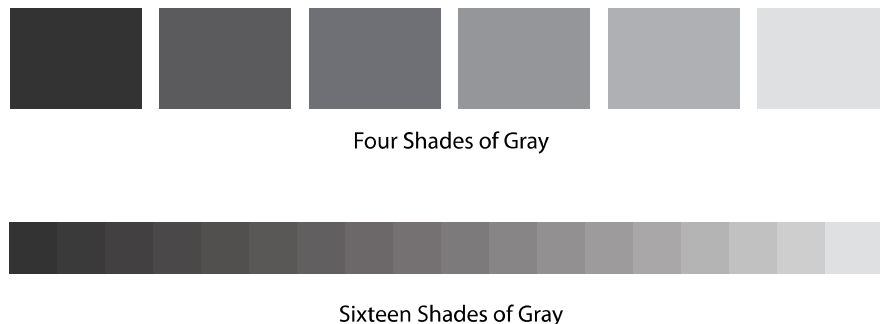
Figure 6: Shades of Gray

Most thermal cameras convert these thousands of gray scales that exceed human vision in a simplistic way, mapping gross areas together that are close in temperature. This is why thermal images often look blurry, lack detail, and conceal intruders.

A better way to perform this conversion would be to emphasize the small variations between objects and the background to exaggerate the fine details and present a clearer image, in contrast to other image features.

This is a processing intensive task. A 320x240 video image contains 76,800 pixels. Each pixel has 14 bits of data, which equates to 16,384 grayscales. These images are updated at

a rate of thirty frames per second to present a smooth video image. Mathematically, the equation is:

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320 x 240 x 14 x 30 = 32,256,000 bits for every
second of video data
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This means that cameras must process over 32 million bits of data every second of the day and night in order to present an image suitable for human vision. Only cameras with sufficient image processing are up to the task.

Clear24 Image Processing Solves Outdoor Challenges

The Clear24 thermal camera is the only outdoor thermal video camera with multiple built-in Digital Signal Processors (DSPs) specifically geared towards presenting a thermal image in a way that is optimized for eye to see. The Clear24 uses image processing from these DSPs to translate the large amount of thermal information into a high contrast image that comes close to black and white photo quality. This can be done day and night, under all outdoor conditions, to address all of the challenges previously described.

When specialized image processing is applied to thermal video, the

following results are produced:

In the example shown in Figure 7, Clear24 image processing is used to intelligently exaggerate the small differences in temperature caused by the rain. In the Clear24 image at right, the person is clearly revealed, along with scene details like the mailbox, circular driveway and street lamp. The market-leading thermal camera on the left left lacks image processing and cannot exaggerate small temperature differences between the person and background. As a result, the image looks washed out, the person may go undetected, and critical details will be missed.


Figure 7: Overcoming Rain and Humidity

Figure 8 shows the impact of thermal loading as objects absorb the sun's energy and heat up, turning white. On the left, the market-leading thermal camera lacks the processing to create good contrast and displays objects as "whited out." On the right, the same image has been intelligently remapped by the Clear24 to emphasize the small temperature differences in the hotter objects, presenting an image that approaches a black and white photo, which is more comfortable to the eye and reveals potential intruders.
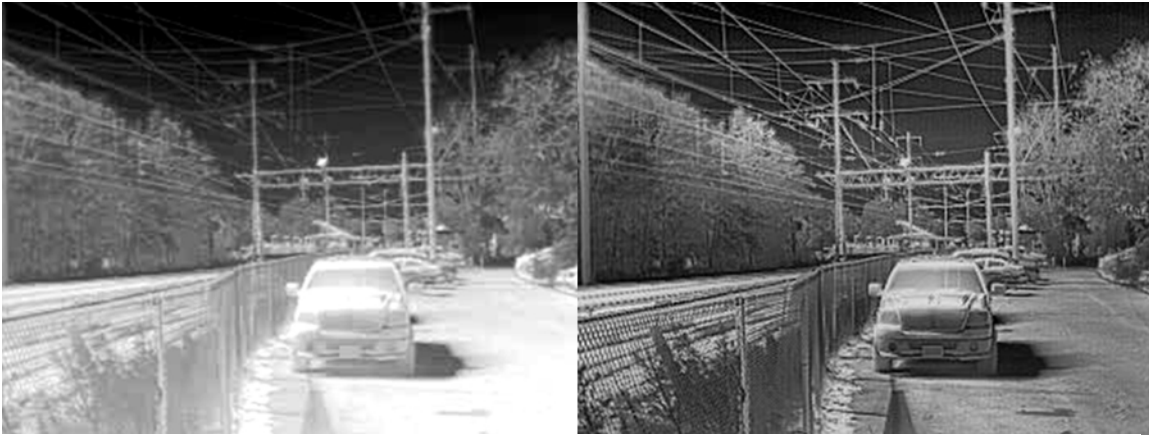
Figure 8: Overcoming White-out and blur

Figure 9 shows how image processing reveals targets against a background of similar temperatures. The market-leading thermal camera on the left is unable to present the person against the cooled background under the canopy. The Clear24 on the right is able to exaggerate the differences and reveal the person.
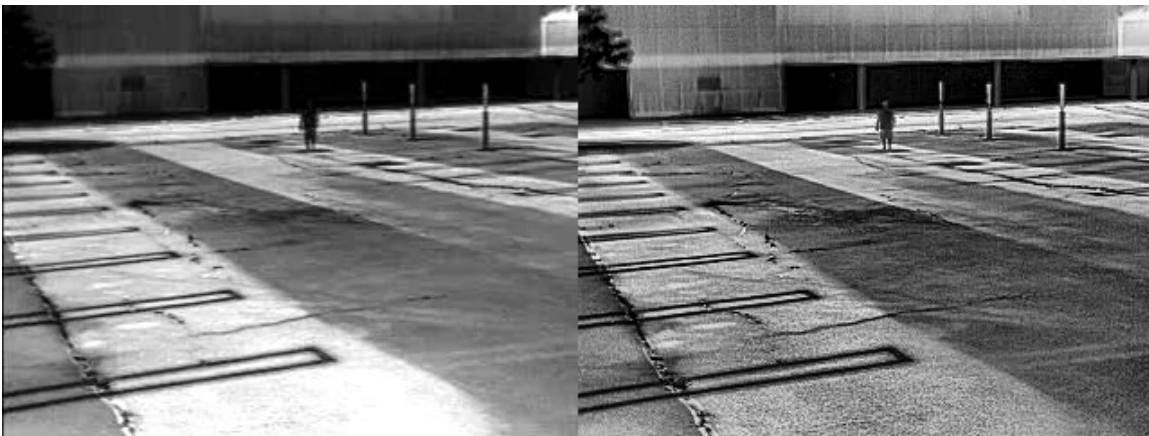
Figure 9: Targets revealed during Thermal Crossover

Figure 10 shows how image processing can enhance the energy from distant objects to produce clear details over long ranges. On the right, the Clear24 image presents the tree line, small boats and cloud cover in the background.

Figure 10: Long Distance Details

Endure Outdoor Conditions

SightLogix Clear24 cameras are specially designed for outdoor use. A sealed, nitrogen-filled NEMA4X-compliant enclosure keeps grit, dust, or moisture from getting in, and ensures maximum performance even in humid conditions. SightLogix cameras are designed to operate in the Canada Oil Sands to the Middle East desert.

Conclusion

Realizing the promise of outdoor thermal imagery requires a solution that reveals what the human eye would miss, is cost effective, and is durable. The SightLogix solution meets these requirements by using image processing technology to:

- Reveal objects that blend into the background
- Eliminate "white-out" to expose targets
- Automatically adapt to low-contrast situations (fog, rain, humidity)
- Obtain clearer details at greater ranges
- Present an image that lowers fatigue and is more natural to the eye

Information and Resources

- Watch a video comparing Clear24 to market-leading thermal cameras: http://www.sightlogix.com/clear24
- Learn more about SightLogix technology: www.sightlogix.com.
- Request a meeting with a solution specialist: Email info@sightlogix.com or call 609.951.0008.

About SightLogix

SightLogix outdoor surveillance systems protect critical infrastructure and key assets of the transportation, energy, utility, chemical, datacenters, public safety, school and religious campuses, and defense industries. The company's SightSensor detection cameras and Clear24 thermal cameras provide full situational awareness to increase both the effectiveness and efficiency of security operations. For more information, visit www.sightlogix.com.

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