SAVER TECHNOTE
Technical Information for the Emergency Responder — March 2005

Thermal Imaging Technology

Background

Night Vision technology has been a common component of military applications requiring object identification in low light and extremely dark conditions. The technology was developed in the 1960's to provide the United States Military with the ability to see at night without using illuminators or searchlights. It has been widely used by the law enforcement community for surveillance, rescue, and forensic operations.

One development in this technology is thermal imaging. Although the cost is higher compared to other night vision technologies, new developments have driven the cost down, making it more available to the average law enforcement community.

Thermal Imaging Technology

Objects around us give off heat to some degree, and that heat is made up of long wavelength infrared radiation that the human eye cannot see. Thermal imaging uses a sensor to convert the radiation into a visible light picture. Not only does this picture help us identify objects in total darkness, or through dense smoke, but the sensor information can be used to measure temperature differences as well.

Thermal imaging cannot be used in applications where the materials absorb long wavelength radiation. Thermal imaging cannot look through common materials such as water or glass.

There are two types of infrared detectors: photon detectors and thermal detectors. Photon detectors usually offer better sensitivity and response times than thermal detectors. However, photon detectors require that the detector be cooled by liquid nitrogen or other means, therefore they are larger, more expensive, and less reliable. Thermal detectors have become the unit of choice in the law enforcement community.

There are many thermal detection processes available, but the two most common are resistive bolometers and pyroelectric sensors. Resistive bolometers are much like complementary metal oxide semiconductor (CMOS) solid state cameras. They have no moving parts, but must periodically recalibrate themselves because they constantly respond to the radiation being produced by an object. Pyroelectric sensors, on the other hand, respond to changes in the radiation of an object. Therefore, they must use a rotating motorized "chopper" wheel to modulate the radiation. This gives them a slight disadvantage to microbolometers because of noise and reliability.

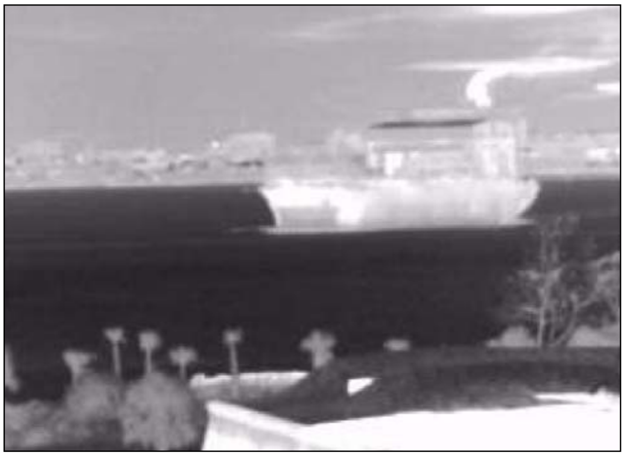
Performance Factors

Thermal detectors are designed to respond to the infrared spectrum, which is broken down into several categories:

Category	Wavelength (microns)
Near Infrared (NIR)	0.7 – 1.1
Short Wave Infrared (SWIR)	1.1 – 2.5
Mid Wave Infrared (MWIR)	2.5 – 7
Long Wave Infrared (LWIR)	7 – 15

Thermal imagers are usually specified for the MWIR or LWIR regions. There are numerous parameters in a detector specification. The most common are:

- **System responsivity** - This is usually in the form of an S shaped curve and will define the range of performance.
- **Noise Equivalent Temperature Difference** - (NETD) - measures the infrared detector sensitivity and should be less than 100mK.
- **Dynamic range** - describes the ability of an infrared detector to produce an image over a wide variety of infrared emissions and should be 60 dB or greater.
- **Wavelength sensitivity** - distinguishes between various wavelengths in the infrared spectrum.
- **Array size** - 160 x 120 pixel array is the minimum that can be used effectively. 320 x 240 or larger is preferred for higher resolution.
- **Detector pitch** - the pixel spacing should be 60 microns or less to achieve adequate sensitivity and resolution.



Applications

Thermal imaging systems offer more than just the ability to see beyond dark applications. The technology provides the ability to detect extreme small differences in temperature with no light or special illuminators and is not limited by smoke, fog, or other particulates. This feature gives the thermal imagers unique capabilities for applications such as:

- Search and Rescue
- Perimeter Surveillance
- Fire Fighting Applications
- Structure Profiles (buildings, tanks, etc.)
- Environmental Law Enforcement
- Hidden Compartments
- Forensics
- Electrical Panels, Motors, Bearings

The suitability of thermal imaging technologies for different operational scenarios may be affected by target characteristics (e.g., stationary or moving). Thermal imaging devices may be mounted to a vehicle or building, or can be handheld.

Thermal imaging is particularly useful at night to locate threats such as suspects, dogs, or other dangers to the first responder. It can be applied to finding lost children, or a fugitive, and locating animals in dense foliage or darkness. These devices are used as force multipliers in search and rescue operations to cover large search areas rapidly and accurately with fewer personnel at less cost.

Other uses for thermal imagery include accurate measurement of skid marks at an accident scene, defining splattered blood location that has been wiped off, positive facial recognition, and defining pollutants in water or air in total darkness.

Emerging Technology

An emerging technology is known as video fusion. This is a process that combines the images from a thermal camera, a charged coupled device (CCD) color camera, and video from night vision intensifiers.

In applications where only thermal imaging and video are fused together, the user has the ability to adjust the image to 100 percent thermal or 100 percent CCD, or any percentage in between. Using this image overlay capability, detail on license plates or the words and logos on security badges can be identified, while still maintaining night vision surveillance. Best of all, this new technology allows the viewer to identify colors and to view through glass.

SAVER is sponsored by the U.S. Department of Homeland Security, Office of State and Local Government Coordination and Preparedness.

For further information regarding this thermal imaging technology overview please contact Eddie Broyles, SPAWAR Systems Center Charleston, Law Enforcement Advanced Technology Engineering, at (843) 218-4423.

Features

Optics (the lenses) on a thermal imager are just as important as the thermal detector. In most devices, the optics will cost more than the thermal imager. Because infrared does not pass through common glass, special materials must be used such as zinc selenide and germanium. The optics used with thermal imagers exhibit the same fundamental characteristics as camera or video lenses. Selection is still made by focal length, f-number, field of view, and material.

Magnification can make the lens very expensive as the focal length increases. Thermal imagers try to use f/1 lenses where the aperture diameter is equal to the focal length. Handheld thermal imagers usually have manual adjustments to the lens, where remote applications require motorized lenses, which drive up the cost.

Monochrome or color displays are often available with thermal imagers. The monochrome displays can be switched to highlight the hotter areas in white or in a darker shade depending on user preference. This is called image polarity. Color displays often come in eight color schemes and can also help identify the hottest regions of the scene.

User Requirements for thermal imagers will vary for different environments and applications. Startup times for thermal imagers may take as long as 30 seconds. Battery life, power consumption, operating temperatures, and weight are all critical factors in selecting a thermal imager.

Legal Issues

Like any new technology thermal imaging is facing an uphill battle in various state and federal courts. Whether or not a person's Fourth Amendment rights are being violated while imaging their residence is in question. In U.S. vs. Kyllo, the case involved the use of a thermal camera to determine that the defendant might have been using heat lamps in his residence to grow marijuana. Therefore, a warrant was required prior to a thermal imagery police search of the exterior of a residence. During the SARS scare of 2004, Singapore and Hong Kong allegedly deployed thermal cameras to scan crowds at airports and other entry points for people with elevated skin temperatures, which would indicate having fever perhaps related to having contracted SARS. There can be legal issues related to such scanning or medical thermal scanning, especially if improper diagnoses are involved. The web site for the Law Enforcement Thermography Association, www.leta.org, has several notes relating to the legality of law enforcement's use of thermography including thermal imagery.