INTELLIGENT SOLUTIONS FOR ENHANCING THE COMBAT CAPABILITY IN URBAN ENVIRONMENT

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Abstract

In this paper is presented a new approach regarding the use of technical achievements in night vision and electronics. The urban conflicts tend to be the major issue in the world war against terrorism. Researchers are developing modern devices that can assure minimal human loss in these kinds of armed conflicts. The use of head mounted display with weapon-mounted off-bore system enables the soldier to detect and fire at targets from behind cover without exposing their head or upper body to the enemy. This paper presents the observations of the authors regarding this subject and preoccupation in developing such a viewing and aiming system.

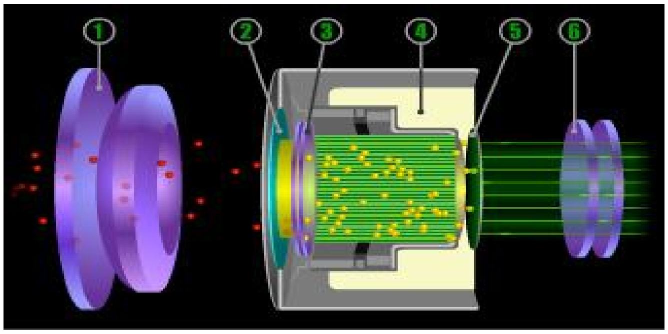
keywords: combat capability, night visions devices, NVDs, weapon-mounted, thermal cameras

1. NIGHT VISION DEVICES (NVDs)

Night vision devices (NVDs) provide night fighters with the ability to see maneuver and shoot at night or during periods of reduced visibility. The Army uses two different types of NVDs – image intensifiers and thermals. Image-intensifying devices are based upon light amplification and must have some light available, even is a very small amount. These devices can amplify the available light from 2,000 to 5,000 times. Thermal Forward-Looking Infrared detectors – sometimes called "thermal sensors" –work by sensing the temperature difference between an object and its environment. Thermal systems are usually installed on certain combat vehicles and helicopters but with the latest achievements this kind of viewing devices became smaller and can be used as light portable devices.

1.1 Image intensifier tubes

Night vision devices gather existing ambient light (starlight, moonlight or infra-red light) through the front lens called objective. This light, which is made up of photons goes into a photocathode tube that changes the photons to electrons. The electrons are then amplified to a much greater number through an electrical and chemical process. The electrons are then hurled against a phosphorus screen that changes the amplified electrons back into visible light that can be seen through the eyepiece. The image will now be a clear green- hued amplified re-creation of the scene that is observed.



1 - Front Lens 4 - High Voltage Power Supply
2 – Photocathode 5 - Phosphorus Screen
3 - Microchannel plate 6 – Eyepiece

Figure 1 – Major components of an image intensifying device

An image intensifier is a vacuum tube device, generally 18-25 mm in diameter. The intensifier comprises a photocathode input, which is a coating of multi-alkali or semiconductor layers on the inside of the input window, and a phosphor screen, which is a fluorescing phosphor coating on the inside of the output window. Also included are either simple grid-shaped electrodes (early intensifier technology) to accelerate electrons through the tube or, in later intensifiers, a complex electron-multiplying microchannel plate (MCP).

Figure 2 – NVD with image intensifier - visualization enhancements

A portion of the incident photons striking the photocathode causes the release of electrons via the photoelectric effect. These electrons are then accelerated (and multiplied in more recent intensifiers) to the phosphor screen, where they strike the coating and cause it to release light. This released light consists of many photons for every incident light photon striking the photocathode surface.

The development of image intensifiers has been primarily motivated by use in the military for night vision. Various types of imagers have been optimized for use in the near infrared (NIR), the main form of night illumination in battle environments. This military influence has led to the adoption of their official convention in the naming of the types of image intensifiers. The types are referred to as generations (Gen) and currently consist of (in order of technology development) Gen I, Gen II, Gen III and Gen IV.

1.2 Thermal Cameras

In order to understand thermal imaging, it is important to understand something about light. The amount of energy in a light wave is related to its wavelength: shorter wavelengths have higher energy. Of visible light, violet has the most energy and red has the least. Just next to the visible light spectrum is the infrared spectrum.

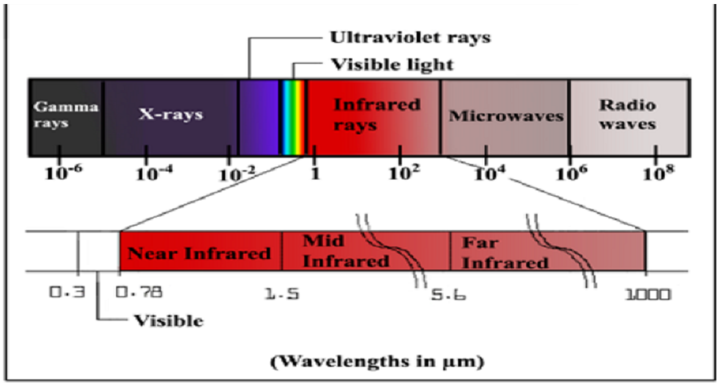


Figure 3 – Spectrum of Electromagnetic Radiation

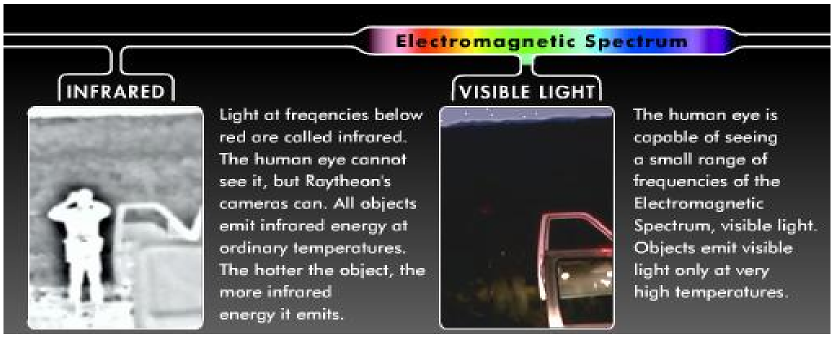
Infrared light can be split into three categories:

1. Near-infrared (near-IR) - closest to visible light, near-IR has wavelengths that range from 0.7 to 1.3 microns, or 700 billionths to 1,300 billionths of a meter.
2. Mid-infrared (mid-IR) - Mid-IR has wavelengths ranging from 1.3 to 3 microns. Both near-IR and mid-IR are used by a variety of electronic devices, including remote controls.

3. Thermal-infrared (thermal-IR) - Occupying the largest part of the infrared spectrum, thermal-IR has wavelengths ranging from 3 microns to over 30 microns.

The key difference between thermal-IR and the other two is that thermal-IR is emitted by an object instead of reflected off it. Infrared light is emitted by an object because of what is happening at the atomic level.

In thermal imaging a special lens focuses the infrared light emitted by all of the objects in view. The focused light is scanned by a phased array of infrared-detector elements. The detector elements create a very detailed temperature pattern called a thermogram. It only takes about one-thirtieth of a second for the detector array to obtain the temperature information to make the thermogram. This information is obtained from several thousand points in the field of view of the detector array

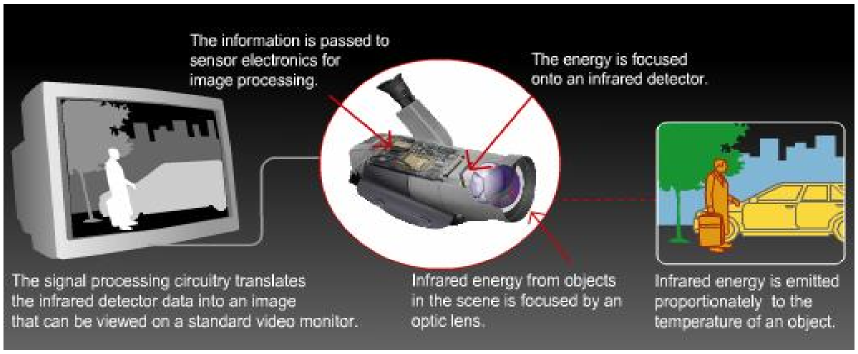


Light at freqencies below red are called infrared. The human eye cannot see it, but Raytheon's cameras can. All objects emit infrared energy at ordinary temperatures. The hotter the object, the more infrared energy it emits.

The human eye is capable of seeing a small range of frequencies of the Electromagnetic Spectrum, visible light. Objects emit visible light only at very high temperatures.

Figure 4 – NVD with thermal sensor - visualization enhancement

The thermogram created by the detector elements is translated into electric impulses. The impulses are sent to a signal-processing unit, a circuit board with a dedicated chip that translates the information from the elements into data for the display. The signal-processing unit sends the information to the display, where it appears as various colors depending on the intensity of the infrared emission. The combination of all the impulses from all of the elements creates the image.



The information is passed to sensor electronics for image processing.

The energy is focused onto an infrared detector.

The signal processing circuitry translates the infrared detector data into an image that can be viewed on a standard video monitor.

Infrared energy from objects in the scene is focused by an optic lens.

Infrared energy is emitted proportionately to the temperature of an object.

Figure 5 – Overview of thermal cameras devices

2. IMAGE INTENSIFIER TUBES WITH CCD

The main role of a CCD (charge coupled device) is to take the signal from an image intensifier tube and transmit it as an electric impulse, so it can be displayed on a screen. The essence of the CCD design was the ability to transfer charge along the surface of a semiconductor.

The intensifier in an ICCD camera can be coupled to the CCD (charge coupled device) either with a lens or a fiberoptic bundle (Figure 6). Lens coupling offers the advantage of flexibility: (1) the intensifier can be removed and the camera used as a standard CCD imager, and (2) an intensifier can be added cost effectively to an existing CCD camera. Disadvantages of lens coupling include lower light throughput (5% - 10%) and increased stray light in the camera system. Coupling via fiberoptics offers better light throughput (>60%) between intensifier and CCD than lens-coupled configurations. Fiberoptic-coupled ICCD cameras are capable of sensitivities approaching single-photoelectron detection and have a much better signal-to-noise ratio (SNR) than lenscoupled devices. Disadvantages are that the fiberoptic coupling is permanent and the detector must be operated in a dry, non-vacuum, inert environment.

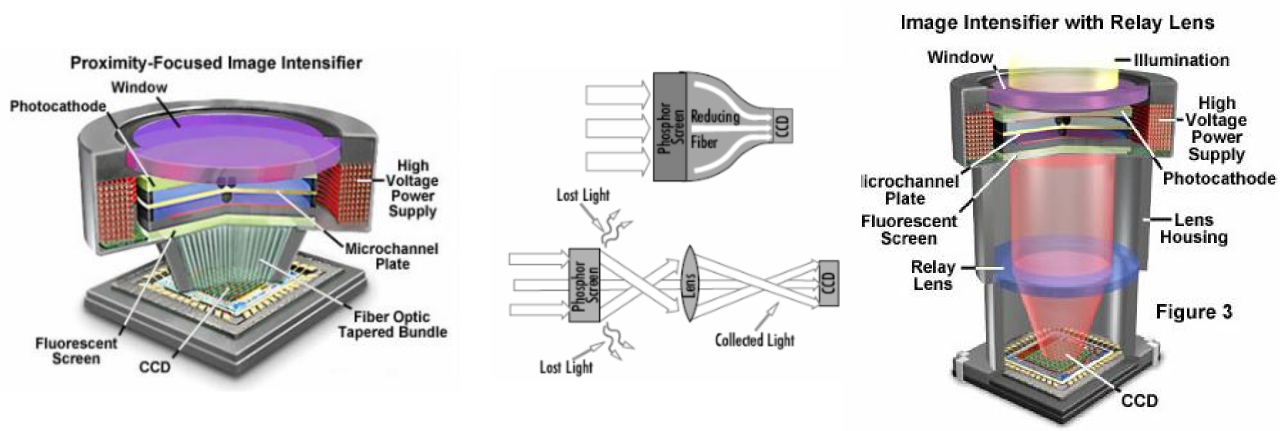


Figure 6 – Image intensifier tubes with CCD

The devices with thermal sensors don't need a CCD because the essence of thermal camera is to display the information on a screen. All the thermal cameras have micro displays or special ports for information transmission to a display. The problem was only with image intensifiers which were developed to display the information on a fluorescent phosphorous display disposed inside the device as part of it. The CCD takes the signal from inside the intensifier tube and transmitted it to an external display.

3. USING HEAD MOUNTED DISPLAYS WITH WEAPON-MOUNTED OFF-BORE SYSTEMS

At the dismounted infantry soldier level, an off-bore video sight, in combination with a helmet mounted display, enables the soldier to detect and fire at targets from behind cover without exposing their head or upper body to the enemy. With only the arms exposed to enemy fire, such "off-bore" shooting offers potential improvements to survivability for the infantry soldier.

Visual display systems for wearable computers have been used by the military for many years. Military aircraft have been using head mounted displays (HMDs) for over 20 years to assist fighter pilots in maintaining visual awareness outside the cockpit and facilitating quick decision making in air-to-air combat. At the dismounted infantry soldier level, several nations have explored the use of HMDs for displaying computer information, sensor information, and weapon sight cameras. Use of a video camera (or a NVD) mounted to the soldier's personal weapon has been explored as a possible means of improving survivability by minimizing soldier exposure to enemy fire. An off-bore sight, in combination with a HMD, enables the soldier to fire at targets from behind cover without exposing their head or upper body. With only the arms exposed to enemy fire, such "off-bore" shooting offers potential improvements to survivability for the infantry soldier.

Figure 7 - Head mounted displays with weapon-mounted off-bore systems

Figure 8 – Weapon sights – Left NVD with image intensifier, right NVD with thermal sensor

The advantages of such systems are obvious in urban environment fights. Another advantage, beyond the fact that the soldier can easily avoid exposure, is that he also has a sight in his field of view and he can shoot to the targets with high precision. This can help the fighter in limit situations when the space is tight (in a building for example or narrow streets) and he hasn't the available time to put his weapon in firing position and shoot with accurate precision.

Figure 9 – A model of head mounted display (example)

Figure 10 – NVD - left with image intensifier, right with thermal sensor

4. FURTHER WORK

In the future we intend to study the possibility of using for weapon-mounted off-bore systems a HMD with a retro-reflective display. The user will be able to see throughout the display, because it will be semitransparent, and in the same time to get useful information on the screen. Another advantage of such a display is that the user sees the projected (the weapon sight or other information) image at infinite so his eye is relaxed and the perception is more accurate.

5. BIBLIOGRAPHY

1. Creţu, E., Mârzu, M., Spulber, C., ,,Sisteme optoelectronice de vedere pe timp de noapte”, Editura Academiei Tehnice Militare, Bucureşti 1999.
2. David W., Edward T. “Using monocular and biocular head mounted displays with weapon-mounted off-bore systems”, Defense and Research Development Canada – Toronto, may 2005.
3. Donal, J., Denvir and Emer Conroy, “Electron Multiplying CCD Technology: The new ICCD”, July 2002, Proc. SPIE, Vol. 4796.

4. Patterson, R., “Perceptual Issues in the Use of Head-Mounted Visual Displays”, Air Force Research Laboratory, Washington State University, February 2007.
5. www.liteye.com.
6. www.microvision.com.