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Night Vision Techniques and Their Applications

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Abstract: *This paper describes the various Night vision techniques."Night Vision" is referenced as technology that provides us with the miracle of vision in total darkness and the improvement of vision in low light environments. This technology is an amalgam of several different methods each having its own advantages and disadvantages. The most common methods described here are Low-Light Imaging, Thermal Imaging and Illumination's. This paper also give brief idea about various night vision device (NVD) that allows images to be produced in levels of light approaching total darkness,it also explains various applications where night vision technology is used to solve various problems due to low light conditions .*

Keywords: *Image intensification, Active illumination, Thermal imaging, night vision technology, NVD*

I. INTRODUCTION

Night vision signifies the ability to see in dark (night). This capability is normally possessed by owls and cats, but with the development of science and technology devices has been develop which enables human being to see in dark as well an in adverse atmospheric conditions such as fog ,rain, dust etc.The muscles in the human eye have the ability to stretch or contract automatically, depending upon the intensity of light falling on the eye. When we go out in bright sunlight, the pupil gets contracted. Alternatively, when we enter a shaded or dark room at that time the muscles of eye relax and make the aperture of the eye lens big enough to allow sufficient amount of light to pass through,therefore the objects in the room appear blurred. Because of this human eye have limitations. The muscles of eye cannot increase the aperture indefinitely. Therefore, in poor light we are unable to see the objects because the image cannot be formed on the retina clearly. The capability to detect and identify targets at night and under poor visibility conditions has been an essential military requirement. The modern army's need to operate at night and under conditions of extremely poor visibility , Since the soldiers have to often fight in the dark at night, they have to face a severe stress as far as the location of target is concerned. Also various wild life observer have to to face problems of low light because many wild animals are more active during night time than day ,therefore to observe there lifestyle and study it night vision is important . Therefore to make human being unable to see in dark by technological means, night vision technology has been developed. This paper describes various techniques and different devices developed to enable viewing in dark.

Night vision technologies can be broadly divided into three main categories:
1: Image intensification
2: Active illumination
3: Thermal imaging

1.1. Image Intensification System

Image intensification systems support direct observations by amplifying low levels of available light. They do not 'turn night into day' Nor do they overcomes the problems that affect vision in low light environments. The image intensifier is a vacuum-tube based device that converts invisible light from an image to visible light so that a objects in the dark can be viewed by a camera or the naked eye. When light strikes a charged photocathode plate, electrons are emitted through a vacuum tube that strike the micro channel plate that cause the image screen to illuminate with a picture in the same pattern as the light that strikes the photocathode, This is much like a CRT television, but instead of color guns the photocathode does the emitting. The intensified image is, typically, viewed on a phosphor screen that creates a monochrome, video-like image, on the user's eyepieces.

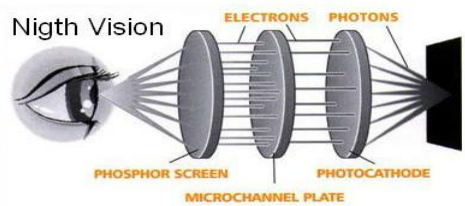

Fig 1: Image intensification systems

Advantages

- Excellent low-light level sensitivity.
- Enhanced visible imaging yields the best possible. recognition and identification performance.
- High resolution.
- Low power and cost.
- Ability to identify people.

Disadvantages:

- Because they are based on amplification methods, some light is required. This method is not useful when there is essentially no light.
- Inferior daytime performance when compared to daylight-only methods.
- Possibility of blooming and damage when observing bright sources under low-light conditions.

1.2. Active Illumination

Active illumination technologies work on the principle of coupling imaging intensification with an active source of illumination in the near infrared (NIR) band. Infrared is used in night vision technology when there is insufficient visible light to see, active illumination involves conversion of ambient light photons into electrons which are then amplified by a chemical and electrical process and then converted back into visible light. Active infrared night vision combines infrared illumination in spectral range 0.7–1 μm. Due to which The scene, which appears dark to a human observer now appears as a monochrome image on a normal display device. Since active infrared night vision systems can incorporate illuminators that produce high levels of infrared light, the resulting images are typically higher resolution than other night vision technologies.

The use of infrared light and night vision devices should not be confused with thermal imaging which creates images based on differences in surface temperature by detecting infrared radiation (heat) that emanates from objects and their surrounding environment

1.3. Thermal Imaging

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.

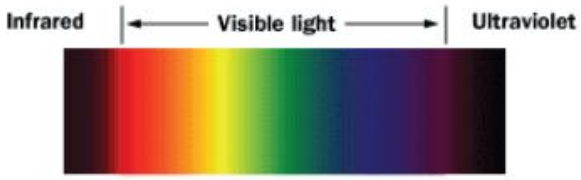

Fig 2: spectrum of light

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 wavelength ranging from 3 microns to over 30 microns.

1.3.1. Working Of 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. The thermo gram created by the detector elements are 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.

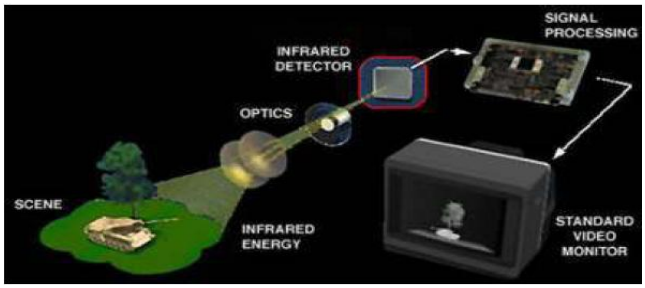

Fig 3: Thermal imaging system

There are two common types of thermal-imaging devices:

i) **Un-cooled** - This is the most common type of thermal-imaging device. The infrared detector Elements are contained in a unit that operates at room temperature. This type of system is completely quiet, activates immediately and has the battery built right in.

ii) **Cryogenically cooled** - More expensive and more susceptible to damage from rugged use, these systems have the elements sealed inside a container that cools them to below 32 F (zero C). The advantage of such a system is the incredible resolution and sensitivity that result from cooling the elements. Cryogenically-cooled systems can "see" a difference as small as 0.2 F (0.1 C) from more than 1,000 ft (300 m) away, which is enough to tell if a person is holding a gun at that distance.


Fig 4: captured image by thermal imaging system

II. GENERATIONS OF NIGHT VISION TECHNIQUES

Table 1: Generations of night vision techniques

S. No.	Generations	Specifications
1	Generation 0	In 1950's,
		Based on Image Conversion, Require source of Invisible Infrared to illuminate the target.
2	Generation 1	In 1960's,
		Based on image intensifier, Larger and heavier systems.
3	Generation 2	In 1970's,
		Micro Channel Plate (MCP) electron multiplier, Development of hand held and helmet mounted goggles.
4	Generation 3	In early 1980's,
		Gallium Arsenide photocathode and ion-barrier film on MCP,
5	Generation 4	In 2000's

III. APPLICATIONS OF NIGHT-VISION

The main purpose for the development of this technology was for the military use, to locate enemies at night. Not only is it used extensively for military purposes, but also for navigation, surveillance and targeting.

Thermal imaging and Image enhancement technologies are used for surveillance purpose by the police and security departments. It is also used for the maneuverability of the hunters and nature enthusiasts through the woods at night. Following are some other applications of the night-vision:

- Law-Enforcement
- Wildlife Observation
- Security
- Hidden Object detection
- Entertainment

1.4. Law-Enforcement

To support law enforcement during the hours of darkness and low light situations and help them detect, deter and prevent the disruption of a enemy. When an event is designated, the Secret Service assumes the role as the lead agency for the design and implementation of the operational security plan. The challenge around events is security on all fronts. During daylight hours and within areas of full light, the playing field is fairly level; however, remove the element of light and someone has the advantage. During events, The challenge is to eliminate low light situations as a potential threat. Prevention, readiness and diligence are the key factors in securing an event from a terrorist threat. Night vision surveillance is a crucial means of protecting an area and its assets before, after and during an event. Night vision techniques give law enforcement the advantage of monitoring activity in darkness and areas of low light. The most effective way to prepare for and provide effective security for an event is to ensure that law enforcement officials have the equipment and training they need long before an event takes place. Therefore with the help of night vision techniques best surveillances can be done in low light conditions.

Fig 5: various night vision devices

1.5. Wildlife Observation

Keen-eyed observer can see much wildlife during the day .but many animals, including most large mammals, are more active at night or twilight. Night-vision binoculars give the option of continuing our observations after the sun has set and the chance to see elusive creatures that are less active during the day. Once a good pair of night-vision binoculars is acquired we can find the best spots to spot critters.

Fig 6: Observed wildlife using night vision technique

1.6. Security

There are lots of challenges in performing video surveillance at night. The optimal solution for a particular application will depend on the requirements for the specific application. For example, is daytime operation required? Does the system need to be covert what is the size and shape of the area to be monitored? Is the goal of the surveillance to detect, recognize or identify subjects in the field of view? The night vision camera provide best surveillance during night or low light condition and thus prevents the chances of theft, terriost attack etc

Fig 7: night vision camera

IV. CONCLUSION

In this paper we have described various night vision technologies which are available and also its working in order to avoid various low light problem, this paper shows that how efficiently a soldiers can work efficiently during night also wild life observer can work during dark and also shown how surveillance can be kept in low light condition .this paper summarize a various generations of night vision technology.

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