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Review Article

# A review of night vision technology

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**ABSTRACT**

Night vision technologies are technologies that enable visibility at a very low light intensity. This paper is on the review of night vision technologies. It covers the concept of night vision technology, different technologies and instruments involved in night vision, the areas of application of night vision, and the drawbacks of night vision technologies. The two major technologies involved in night vision, image enhancement, and thermal imaging were also explained. It finds great application in the military, law enforcement, and other security systems to mention but a few. Its major drawback is the cost of the device.

**Keywords:** Enhancement, image, light intensity, night vision, technology, thermal imaging

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## INTRODUCTION

Night vision technology simply allows one to see in the dark. The work in Anshil[1] defines night vision technology as the expertise that makes us capable to see in the night without using any external light source such as a torch or a lamp. He stated that this technology makes use of highly advanced light sensitive cameras that produce clear visible images at night which the naked eye cannot produce. The work[2] explained that from observations, it was discovered that the muscles in the human eye have the ability to stretch or contract automatically, depending on the intensity of light falling on the eye. This is because the lack of tapetum lucidum (Latin word meaning bright tapestry) which reflects visible light back through the retina, increasing the light available to the photoreceptors.[3] The author in Kumar[4] suggested that a good understanding of light is necessary for one to understand night vision. He went further to state that the amount of energy in a light wave is related to its wavelength: Shorter wavelength has higher energy. In visible light, violet has the most energy and red has the least.

Naturally, night-vision capability is possessed by nocturnal animals such as owls and cats. Many animals have better night vision than humans as a result of one or more differentials in the eyes' anatomy such as larger eyeball, a larger lens, and improved neurological filtering to mention a few. Due to technological advancement, a lot of devices have been developed which enables an individual to see in the dark and in an adverse atmospheric condition such as fog, rain, and dust. The German Army was first to introduce night-vision devices (NVDs) on the battlefields[5] in the mid-1930s. It was used by the first panther tanks in the mid-1940s. The first commercial NVD was created by Dr. Vladimir K. Zworykin, who was working for Radio Corporation of America at the time.[5] It was intended for civilian use, it was not a commercial success because of its size. Federal and state agencies, now generally make use of this technology for site security, surveillance as well as search, and rescue. In recent times, night vision technology is being used in our day to day life.

Night vision technology finds great application in military, navigation, surveillance, and targeting. Urban and rural police force made use of the technology. Hunters and nature lovers use NVDs to maneuver through the woods of the night. In thick forests like the Sambisa forest in Northern Nigeria, notorious as a Boko Haram enclave, night vision is very crucial in military surveillance and counterattacks at night since most of the attacks by this group are carried out in the night. NVDs can be used to track criminals or individuals under surveillance. They are also used for security purposes in businesses. With its thermal imaging capability, it is easy to discover if the earth has been disturbed to bury explosives, stolen properties, dead human beings, or even charms in African countries where such practices are prevalent even when there are no obvious traces.

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## TECHNOLOGIES USED FOR NIGHT VISION

### Image Enhancement

Most night-vision equipment use image enhancement technology. The image enhancement devices are called NVDs. These devices use an image intensifier to collect a tiny amount of visible light available in the dark, including the lower portion of the infrared (IR) light that is present but imperceptible to the human eyes. The reflected low light may originate from natural sources such as starlight, moonlight, or from artificial sources such as street light. It amplifies this light to a point that one can easily observe the image.

#### *Stages in image enhancement*

*Capturing*

A conventional lens called the objective lens captures the ambient light as well as some near – IR light. The captured light is sent to an image intensifier tube which gives an output voltage of about 5000 volts.

*Conversion*

At this stage, the photons of light energy are converted into electrons by the photocathode of the tube which also emits its own electrons, thereby increasing the amount of electrons generated to about a thousand.

*Image creation*

The electrons impinge on a phosphor-coated screen at the end of the tube while maintaining their position in relation to each other, causing a release of photons leading to the creation of a green image on the screen of the device. The green color is preferred because of the human eye's high sensitivity to green color. The ocular lens then magnifies the image for direct viewing or viewing through a display. It is worthy of note that image enhancement is ineffective in complete darkness [Figure 1].

### Thermal Imaging

Thermal imaging cameras make a picture from heat not visible light. Heat is also a part of the electromagnetic spectrum just like light, but a camera used for detecting heat cannot detect visible light and vice versa.[6] Thermal cameras detect not just heat but also differences in heat and display them as shades of gray or other colors.[6] This technology operates by capturing the upper portion of the IR light spectrum, which is emitted as heat by objects instead of simply reflected as light. It is known that all objects emit IR energy as a function of their temperature, and the hotter an object is the more IR radiation it emits. This IR radiation is converted into a visible image. There are many thermal imaging cameras that use different colors to indicate objects having different temperatures.

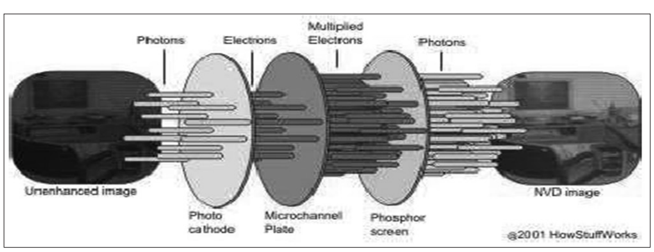


**Figure 1:** Stages in image enhancement[4]

#### *Steps in thermal imaging*

*Focusing of light*

The IR light emitted by the objects is focused by the lens and is scanned by a phase array of detectors whose elements create a very detailed temperature pattern called a thermogram.

*Electronic impulse creation*

The thermogram created by the detector is converted into electronic impulses which are sent to a signal processing unit that translates the information from the elements into data which are prepared for display.

*Image creation*

The information sent to the display unit can be seen as different colors depending on the intensity of the IR emission. The image is created by the combination of all the impulses from all the elements [Figure 2].

#### *Types of thermal imaging devices*

Thermal imaging devices are of two types: The uncooled and the cryogenically cooled devices. The uncooled thermal imaging device is the most common and operates at room temperature. The operation of the camera is noiseless (i.e., no sound is heard). The cryogenically cooled system is more expensive, more fragile and the elements are sealed in a container that maintains the temperature at 0°C during operation resulting in higher resolution and sensitivity. It can detect a temperature difference of 0.1°C from a distance of about 300 m away from the object. As a result, it finds good application in military and security systems because at that distance, it can detect if a person is holding a weapon [Figure 3].

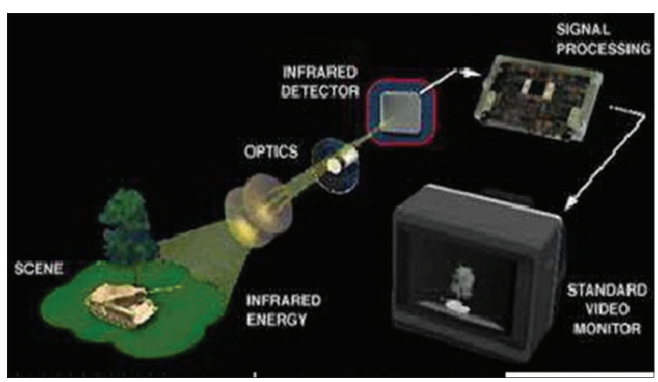


**Figure 2:** Basic components of thermal imaging system. Source: Haque and Muntjir[7]

Note that although thermal imaging is great for detecting people, or objects in near-absolute darkness, most night-vision equipment use image enhancement technology.

## GENERATIONS OF NIGHT VISION TECHNOLOGY

NVDs have been in existence as early as 1929. Over the years, technology has evolved resulting in several generations. Each change in night vision technology establishes a new generation.[8]

### Generation 0

In 1929, Hungarian physicist Kálmán Tihanyi invented an IR-sensitive electronic television camera for anti-aircraft defense in the UK.[9] The first military NVDs were introduced by the German Army as early as 1939 and were used in World War II. This generation of night-vision products was based on image conversion, rather than intensification. They required a source of invisible IR light mounted on or near the device to illuminate the target area.[10] The disadvantages of this generation are the distortion of the image due to the acceleration of the electrons and the short life cycle. Another major disadvantage is duplication by hostile nations.

**Figure 3:** Image produced by thermal imaging system
Source: Haque and Muntjir[7]

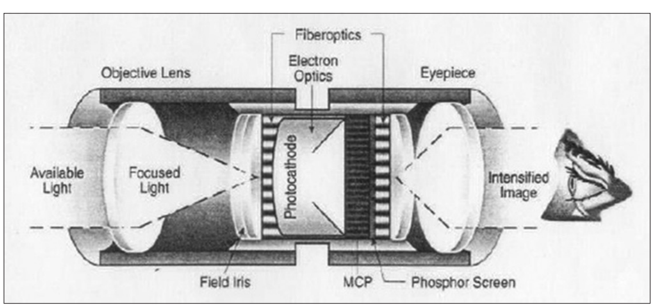


**Figure 4:** Generation 2 night-vision device system.
Source: Haque and Muntjir[7]

### Generation 1

This generation has three image intensifier tubes connected in series. These systems are larger and heavier than Gen 2 and Gen 3. The Gen 1 image is clear at the center but maybe distorted around the edges. The Generation 1 devices used passive IR instead of active IR. The major disadvantage was that they could not work very well on cloudy or moonless nights.

### Generation 2

This was developed in 1970's. There was a major improvement in Generation 2 image intensifier tubes. Their performance and resolution was better than that of Generation 1 devices and they are considerably more reliable. They can see in extremely low light. The addition of the microchannel panel plate to the image intensifier tube, as shown in Figure 4, eliminated the need for back to back tube, leading to improved size and image quality. The plate enabled the development of handheld and helmet-mounted goggles.

### Generation 3

The US military made use of Generation 3. There was much improvement in the resolution and sensitivity because the photocathode was made with gallium arsenide, which enables the detection of objects at greater distances under much darker conditions. The life of the tube is increased by the ion barrier coating on the tube.

### Generation 4

They are referred to as filmless and gated technology. The automatic gated power system enables the device to respond to light fluctuations, i.e., the user of the device can move from an area with high light intensity to an area with low light intensity without any effects on image quality. To improve the signal-to-noise ratio, the ion barrier was removed. This allowed more electrons to get to the amplification stage so that image brightness is increased and distortion reduced.

Note that Generation 2, 3, and 4 devices are usually very expensive, but they last longer. Any NVD can benefit from an IR illuminator in very dark areas where there is almost no ambient light to collect.

## NVDS

NVDs can be classified into:

a. Night-vision scopes: These devices are either handheld or mounted on a riffle and are mostly used by shooters and hunters. They have one eyepiece. They are more useful for viewing specific objects. Figure 5 is the picture of a pocket scope
b. Night-vision goggles: They are binocular devices with single or stereo lens mostly worn on the head. They are good for constant viewing, such as moving around in the dark building. Figure 6 is the picture of a Google

**Figure 5:** Dark Invader multipurpose pocket scope. Source: www.bemeyers.ccom[11]

**Figure 6:** Dark Invader night-vision goggles 4501. Source: www.bemeyers.ccom[11]

**Figure 7:** Stealth 301 series day/night video camera. Source: www.bemeyers.ccom[11]

c. Night-vision cameras: They have the ability to send images to a monitor for display or to a recording device. The newest camcorders have built-in night vision technology in it. They are used in buildings or as part of equipment in a helicopter [Figure 7].

## APPLICATIONS OF NIGHT VISION TECHNOLOGY

1. Military: NVDs were developed originally for military use during warfare. They made use of hand-held sighting scopes, weapon scopes, and night-vision goggles
2. Law enforcement: They find applications in search and rescue operations, surveillance, apprehension, forensics, hazardous material response, tracking, and navigation
3. Wildlife observation: Night-vision binoculars enable observations at night especially for the animals that are more active at night
4. Surveillance: There are lots of challenges in performing video surveillance at night. The night-vision camera provides the best surveillance during the night or low light condition and thus prevents the chances of theft, terrorist attack, etc.
5. Hunting: Hunters and nature enthusiasts use them to maneuver through the woods at night
6. Navigation: Thermal imaging devices are more commonly employed in fire and rescue applications because the ability to sense heat is fundamental to firefighting procedures. Thermal imagers are used to help locate victims, safely navigate smoke-filled buildings, and detect the hottest parts of a fire scene
7. Hidden-object detection
8. Security: They provide the user with the capabilities of long-range detection, covert surveillance, use in harsh environmental conditions, and greater sensitivity in dark locations.

## DISADVANTAGES OF NIGHT VISION TECHNOLOGY

The disadvantages of NVDs include their inability to see through transparent obstacles and the fact that they are very expensive. The cost is still the major factor limiting their widespread use. It is believed that with the development of better technologies and improved processing efficiency, the cost will be greatly reduced in the future.

## CONCLUSION

NVDs were basically designed for military purposes, but their application to scientific or civilian use is often prohibited by law. Night vision technology is very essential in combating kidnapping and terrorism, which is a major problem in Nigeria. The night vision technology is gradually becoming more appealing to the non-military consumer market. While prices are still high, as demand increases, the price may decrease until the technology is fairly affordable. The technology is already being used by law enforcement and search-and-rescue teams. As the products become cheaper, more photographers, wildlife watchers, boaters, campers, and many others may begin to use night vision technology in more innovative ways.

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