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THE STUDY OF TECHNOLOGY TO BEAT THE DARK

[1]Arthie Reena.R, [2]Nushrath Sameera, [3]Afroz Begum.SK
[1,2,3]Electronics and Communication Engineering, Vasavi College of Engineering, Hyderabad

Abstract -"Night Vision" is the 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. Night vision technologies can be broadly divided into three main categories as Image intensifier, Active illumination, Thermalimaging. The night vision technology uses the advantages of both the image intensifiers technology and infrared sensors technology. Image intensification gives a clear image, very good resolution, very good target identification probability. Electronic Image Intensification began in the early 1930s but became more widely available in the 1950s with the introduction of the Infrared image converter tube. The Infrared sensor gives the ability to see practically, under any environmental conditions. Infrared devices have been developed for use of services. These are either "active" devices or "passive" devices. In active devices, the user carries a source of infrared radiation and illuminates the target with invisible light. These devices are invariably image forming. The infrared image of the target is converted to a visible image with the help of a suitable device. In passive devices, the natural and characteristic emissions from the targets are utilized for the detection of the target. These are essentially non-image forming type[30]. In this work, literature on the Night Vision Technology spanning six decades from the 1950s to the 2010s is identified, categorized and analyzed. The publications are divided among the most prevalent topics being Technologies, Devices and Generations. It finds its application in various fields such as Military, Law enforcement, Hunting, Wildlife observation, Surveillance, Security, Navigation, Hidden-object detection.

Keywords- Night Vision, Image Intensifiers, Infrared sensors,Active device and Passive device, Application.

I. Introduction

Night Vision Technology has evolved over the past few decades. It 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 condition 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 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[26].

Image intensifier has high resolution but it requires some light source. Active illumination method used at short distance range and known as active system, whereas thermal imaging method used for long distance range and known as passive system. Active system used with Near Infrared camera [NIR] and passive system used with Far Infrared camera [FIR].

II. Technologies

James A. Ratches (2006) - discussed the operational applications, current systems approaches and technical goals. The potential breakthroughs of the techniques are identified. He had also suggested that these Research opportunities could enable new system capabilities, including areas of advanced active thin film research. This paper is addressing the pursuit and progress of each of the technical areas, such as all solid state low light level TV cameras, mercury cadmium telluride IR detectors on silicon substrates, uncooled thermal imaging, eye safe laser imaging and aided target recognition[27].

Chuang Zhang (2006) -The dual-spectrum night vision fusion technology mainly includes the LLL and the infrared image fusion, the LLL and the ultraviolet image fusion, the LLL and the laser assistant image fusion as well as the dual-spectrum LLL image fusion, the NRL method and the TNO method. In night vision technology, the dual-spectrum fusion is mainly used to enhance the target identification probability. This paper had used the gray-

[1]Corresponding Author

scale modulation method and the spectrum field method to carry on the quality appraisal. He had analyzed the results of the LLL and the infrared images appraisal, the LLL and the ultra violet Images appraisal, the LLL and the laser assistant image the appraisal and Dual-spectrum LLL image appraisal methods. Regarding the dual-spectrum night vision fusion image quality appraisal, has used the subjective observation probability, the signal to noise ratio and the gray-scale accrete matrix three appraisal methods according to the night vision technology target[28].

Jason M. Kriesel (2010) – discuss a system that produces fused night vision imagery with true-color information. He described a fully functional, prototype night vision camera system which produces true-color imagery, using a visible/near-infrared (VNIR) color EMCCD camera, fused with the output from a thermal long-wave infrared (LWIR) microbolometer camera. The fusion method is performed in a manner that displays the complimentary information from both sources without destroying the true-color information. An embedded processor is used to perform the fusion in real-time at 30 frames/second. It produces both digital and analog color video outputs. He discussed the true-color night vision cameras and specifically the EMCCD camera used in the system, general consideration for maintaining true color in a fusion system and True-Color Night Vision (TCNV) Fusion prototype system[20].

Teresa Telesco(2012) - In 2009, President Obama's review found that the current system is overly complicated, contains too many redundancies, and tries to protect too much, affecting the U.S. Government's (USG) ability to adequately control and protect key items and technologies that are crucial to U.S. national security. To conduct the assessment, Bureau of Industry and Security(BIS) developed a survey to determine the nature of night vision components and equipment manufactured for military-use-only and dual-use (for both commercial and military use). This assessment focuses on sensor components (e.g., FPAs, IITs, LLL sensors) and imaging equipment incorporating sensor components. Force protection and missile tracking, guidance, and seeker/countermeasure were listed as specific application categories for thermal imaging military-use. This report concludes that Military-use night vision components and equipment have different physical and technical characteristics than dual-use night vision components and equipment (e.g., weapons mounting, stability software, special packaging)[18].

RupeshP.Raghatate (2013) - gives the brief idea about various night vision devices (NVD) that allows images to be produced in levels of light approaching total darkness. He explains the technology that solves various problems based on low light conditions. Methods described here are Low-Light Imaging, Thermal Imaging and Illumination's. He specifies the application in various fields like Law-Enforcement, Wildlife Observation, Security, Hidden Object detection, Entertainment. He shows how surveillance can be kept in low light condition and summarizes a various generations of night vision technology[26].

C.Plesa (2015) - investigates how the Chalcogenide glasses (Ge30As13Se32Te25) influences the image quality when it is used as a combination of lenses. A cost-effective, high performance alternative to germanium in many infrared optical designs that demand consistent performance, with minor defocusing, across broad temperature ranges has been analysed by usingChalcogenide glasses.Chalcogenide glasses are mainly composed of cheap and abundant selenium with germanium content ranging from 20% to 33% (atomic percentages).It has been concluded that the Chalcogenide lens could be a solution for night vision objective offering approximately the same image quality like germanium. The good image quality of the virtual prototypes has proven that chalcogenide lens molding is a viable technology for night vision applications. Chalcogenide materials can be the future prospective materials which would provide less expensive technical devices in the field of night vision electro-optics, offering high transmission quality across a wide range of the infrared spectrum, from the near-infrared (NIR) to long wavelength infrared (LWIR) regions and low glass transition temperatures[24].

Gang Liu, Guohong Huang (2010) proposed a new multi-scale scheme for color image fusion using EM algorithm and color transfer algorithm for IR and visible image. The high frequency band of the visible and IR images and low-frequency band of the visible and IR images are separately fused using minus operation. Then fused lowest frequency band and the fused high frequency band are obtained.

Final fused image can be achieved by performing non-subsampled contourlet domain by using EM algorithm. Then color transfer is implemented using YUV color space to make the final fused image. The advantage of Color Fusion Based on EM Algorithm is, it gives very abundant detail information and the color metric representation is better than the other method. Drawback is, low color contrast problem between hot target and cold target[29].

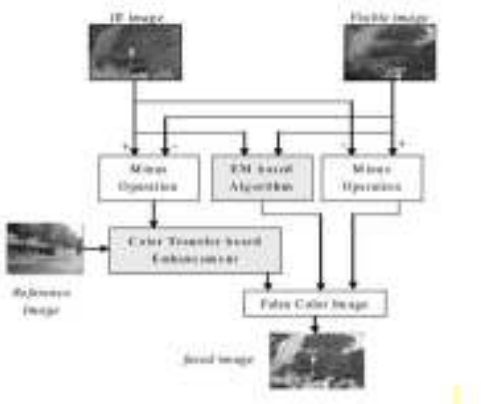

Fig 1 Color Fusion Based on EM Algorithm method.

Source: JenithaChristinal.J (2012)

J.JenithaChristinal (2012) surveyed and compared on different multi-band fused image based on its image fusion method and color transfer method. The methods such as Local-Coloring method, Fast Natural Color Mapping Method, One Color Contrast Enhanced Method, EM Algorithm, Adaptive Color Fusion Method, Fast Color Contrast Enhancement method and Efficient Color Transfer Method are briefly discussed[10].

D.W.Swift (1972) gives a brief general survey of methods and devices intended to augment the performance of the eye under low illumination conditions. He has made an attempt to present a coherent andbalanced picture of the current situation in night vision[11].

Soundarya. P (2016) had discussed about the techniques and applications of Night Vision. Thermal imaging works by observing temperature produced by objects. The warmer object appears white and cool object appears in black color,but the resultant image produced by thermal image is not clear due to its weak signal. To overcome this, double spectral and image fusion algorithm is used. Thermal imaging has image sensor used to detect the range of the wavelength[14].

Xia Liu (2004) describes a method for pedestrian detection using a stereo night-vision system installed on the vehicle.It makes use of shape information. He proposed two new techniques, namely two stage method for stereo correspondence and motion detection without explicit ego-motion calculation.In this paper, she reported on pedestrian detection using stereo-based night vision. At night, exposed parts of the human body appear hotspots in the heat-sensitive infrared vision.This method based on stereo has three major steps.These steps are establish the frames,establish object correspondence between frames, and decide which objects are independently moving. For this algorithms used are Two-Stage Algorithm for Object Correspondence, Moving Object Detection without Ego-Motion Computation. This paper concludes the problem from the viewpoint of moving-object detection on night vision.Shemade a technique, made use of movement information by pedestrians, especially when crossing the street.In general, a motion-based approach is computationally faster for detection and does not rely on any training data. For a pedestrian hidden by an umbrella, as long as some part of the pedestrian can be detected as a moving blob, this method can find his movement[5].

Tsz-Ho Yu (2009) describes an intelligent night vision system for automobiles in this paper. This system, implemented mainly by adopting infrared cameras and computer vision techniques, aims at enhancing safety and convenience of night driving by providing functionalities such as adaptive night vision, road sign detection and recognition, scene zooming and spotlight projection. So he had tested the system in both simulated laboratory environments and in field highway environments. Facing the problems, such as bad weathers, obscure street lamps and limited range of headlights, so attentions have been attracted to the research of automobile night vision systems which help to improve the visibility of objects on the road at night .To adapt with different driving requirements, we have implemented four major functionalities in IVAN. Adaptive night vision, Road sign detection and recognition,Spotlight projection, Scene zooming.He had concluded real time road sign detection and headlight tracking features can provide more information of the road to the user[3].

HaoSun (2011) described a night vision pedestrian detection system for autonomous vehicles using an onboard forward-looking infrared (FLIR) camera. He proposed effective sub-windows scanning, a novel keypoint based region of interest (ROI) selection strategy in IR imageries.Experimental results under different urban scenarios proved that the proposed system is robust and efficient. The proposed system has been tested on various IR video sequences containing multiple pedestrians at different time. He concluded that a night vision pedestrian detection system for autonomous vehicles is presented using an onboard forwardlooking infrared (FLIR) camera. He utilized Haar-like features, which areextracted to discriminate infrared pedestrians ,AdaBoost learning algorithm is employed to select the most relevant infrared pedestrian-specific features and finally a keypoint based sliding window cascade classifier is utilized for effective pedestrian localization[6].

Ciaran Hughes discussed vehicular safety in two key concepts.As the vehicle engineering aspects which as far as possiblereduce the risk of an accident occurring in contrast, other safety which is ‘all structural and design features that reduce the consequences of accidents as far as possible. He had discussed the on-vehicle use of camera systems.He concluded that with increasing

numbers of vehicles on the world's roads, statistics show that a significant percentage of traffic fatalities are caused by drivers who are not aware of VRUs and other road users. While small vehicles are exempt from current European and Japanese legislation, US legislation specifically targets the smaller private vehicles. Ultimately, camera systems will be necessary equipment for improved visibility around vehicles, particularly SUVs and LGVs, where the blind-zones are substantial. As wide-angle/fish-eye camera systems are currently the best candidates, because of their ability to display even the largest blind-zones of a vehicle .He discussed ADAS applications .Though these are only the more popular applications ,Camera systems will soon be as common place on vehicles as climate control systems or antilock braking systems[4].

AMEYA CHAVAN (2016) signified the ability to see in the dark (night) where only low beam head lights used nowadays This technique is helpful for a human sight to be able of seeing even in rain, fog and dust with the help of night vision display. Automatic night vision system is used to increase driver's perception and seeing distance in darkness beyond the reach of vehicle headlight.Heexplained, it senses the disturbances in its electronic signals and sends it via cable to the LCD screen helping the driver for convenience.. Along with this, even animals are primary safety goal of night vision system.He concluded that automatic pedestrian warning in the form of highlighting the pedestrians in the Night Vision System is genuinely helpful in increasing detection distance and accuracy. He had described implementation of night vision technologies which are available nowadays and also it's working in order to avoid various low light problems occurring often[7].

SumitKarn(2016) explained that the reckless accidents that occur on roads during night times mainly owe to the poor visibility and make the drivers rather than driving ahead, predict their way ahead and also sensible drivers who find very bad visibility during the week hours of morning or the odd evenings .Thus comes the use of night vision systems which uses infrared sensors or headlights to provide a clear view of the road ahead and in the coming sections. He discussed about Electronic spectrum and LCD monitors used by NVDS.He concluded that,to put it in a nut shell it has become the need of the hour to have these kinds of hybrid safety systems on the latest automobiles that could save the lives of many.All the automobile giants should divert their R&D work towards such innovative technologies and make this world a safer world to live in[31].

James D. Murdoch Ralls Cypher (2003) The, research on kit fox behavior has focused mainly on data obtained indirectly through radio telemetry, diurnal den watches, and limited observations of captive or trapped foxes. Few investigation shave focused on aspects of kit fox biology that require continuous direct observations at night.They explained night vision technology along with radio telemetry to investigate aspects of urban kit fox nocturnal behavior, including scent marking, vocal communication, and behaviors associated with intra specific and inter specific interactions.They employed a commercially available night visionmodular pocket scope with an ANVIS-style generation III image intensifier tube. They concludedthe use of nightvision equipment could greatly assist in monitoring na-tal dens to yield more accurate litter counts. Night vision technology could also facilitate investigations into the unstudied nocturnal behaviors of other rare North American carnivores such as island fox (Urocyonlittoralis),swift fox (Vulpesvelox), and badger[2].

Lavers C (2005) applied advanced electromagnetic sensor systems more commonly associated with the high-tech military battlefield to remote surveillance of wildlife. He presented some of the veterinarian advantages of, such all-weather day and night systems to identify sickness and injuries at an early diagnostic stage, as well as age related effects and mammalian cancer.NIR camera demonstrates they can remotely evaluate a broad range of endangered and vulnerable wildlife species in captivity without stress, applicable to environmental management and evaluation in the wild. He representedpreliminary test work and initial image analysis and zoo thermal work. He had demonstrated some key benefits of using thermal and NIR imagery in safe wildlife observation, diagnostics, and camouflage considerations. He concluded future aim will be to acquire complementary images of selected wildlife scene over a long period in at least 3 spectral bands: Visible, NIR, and FIR and to observe any trends [1].

Omer Tsimhoni(2004) explained near infrared (NIR) systems and far infrared (FIR) systems.which generate images by passively detecting thermal emissions from objects and surfaces in the road scene.He discussed video manipulation.The process of extracting video clips was intended to convert the collected video footage to digital clips of manageable size and to achievesimilar screen size and frame rates between the camera types while minimizing image degradation. Digital video from DVCAM tapes was transferred digitally to a PC and saved in raw audio video interleave format.Heexplainedthe purpose of this experiment was to make a direct comparison of FIR and NIR systems based on how well they can help drivers detect pedestrians at night.The results supported the expected enhancement of pedestrian detection in FIR systems relative to NIR system.He concluded that this counterintuitive finding suggests that, FIR systems have an important advantage over NIR systems in that there is less clutter to delay the

decision about the presence of a pedestrian in the image [15].

Waxman.A (2006) generated real-time fused combinations of VNIR, SWIR and LWIR imagery enhances situational awareness, task performance, and overall image quality. Task performance has also been assessed in two field collection campaigns, and multiple human performance tests in the lab using field data.He predicted human performance for different tasks Image Fusion & Image Quality, Local Adaptive Contrast & Gain, Noise-Limited Resolution, Detection Modeling, and Color-Fused Filling.He concluded that fused image quality spans multiple dimensions: quantitative metrics, perceptual metrics, and task specific metrics. Here image quality is influenced by the choice of sensors, the prevailing illumination and thermal conditions, and the kinds of enhancement and fusion processing being applied to the data.He proposed Image quality models try to capture the phenomenology, relating sensor parameters and natural conditions to various measures of image quality[12].

Zhang.J.W(2009) explained the two atmospheric "windows" where IR transmission is high: mid-wave and long-wave windows.He proposed entire system design, including optics and electronic aspects, was investigated. The pyroelectric properties of OC materials for this night vision enhancement application were evaluated. He simplified thermal diffusion from the neighboring pixels through the substrate and LC and the thermal noise from surrounding temperature fluctuations can raise the NETD considerably. To verify the feasibility of the new thermal detector concept, he made a 2 x 2 detector, a red incandescent lamp was chosen as the illumination light source.the electric field stemming from the pyroelectric effect in a pyroelectric material varies with ambient temperature simply because the pyroelectric coefficient is temperature-dependent.He concluded that a new night vision technology was successfully demonstrated and characterized.it is a completely new thermal imaging technology, efforts need be made to develop the proposed fabrication procedure .He determined the associated governing parameters and continued efforts are needed for this new material to be implemented in commercially viable products[17].

Timothy Brown (2010) explained thatpedestrianfatalities,as a result of vehicle collisions are much more likely to happen at night than during day time.Use of automatic warnings(AW) may help minimize workload, improve performance, and increase safety. In this study, we used adriving simulator to examine performance differences of a NVES with six different configurations ofwarning cues, including: visual, auditory, tactile, auditory and visual, tactile and visual, and nowarning. He discussed there are mixed findings when trying to assess the impact of the use of AWs on improving driversafety in terms of avoiding collision with pedestrians.As can be seen,there is an increase in response distance when auditory or tactile warnings were used, but there is adecrease when a visual warning was used. He concludedthat automatic warning for Night Vision Enhancement Systems can have a positive impact on improving pedestrian safety by allowing drivers to respond at a greater distance. It appears that the visual-box warning does not improve driver's performance, while the auditory and tactile warnings improve driver's performance.The single modal warning conditions of auditory only and tactile only are more effective than the dual-modal conditions of auditory-visual and tactile-visual.He resulted from previous research and our study point to a conclusion that, the types of warnings that do not rely on the driver looking into the video display, such as auditory, tactile, or LED light cues, are more effective than visual types of warnings that have to involve video displays [13].

JenithaChristinal.J (2013) introduced the IR image records the thermal radiations emitted by the objects in a scene and, can be utilized to discover targets as it has better hot contrast and can present camouflaged targets.She explained that a Fusion of IR and visible images with different contents could be utilized to enhance the image quality. . The fusion goal in surveillance is to enhance the interesting objects visible in thermal images against the visible image surroundings.Themethods used are Local Coloring method,Fast Natural Color Mapping Method, One Color Contrast Enhanced Method, EM Algorithm, Adaptive Color Fusion Method, Fast Color Contrast Enhancement method. She discussed about Fusion of Infrared and Visible Image, Image Enhancement and image fusion, color transferring technique .She proposed a simple and fast fusion approach for night vision image. She explained that before fusion, the quality of both visible image and Infrared image is improved by using the Local Histogram equation and then the images are fused. She concluded that to get the natural color image, the color is transferred from the reference image to the fused image by using Lab color space and the contrast between the target and the background is enhanced using a scaling factor. So the hot targets are popped out with intense red colors while the background details present with the natural color appearance [16].

III. Devices

Michelle Sylvia Gauthier(2008): had examined the effects of night vision goggles (NVGs) on navigation and way-finding performance and the acquisition of spatial knowledge. The aim of this study reported here was to systematically assess the impact of using NVGs on the acquisition of spatial knowledge in addition to the impact

on spatial way-finding performance. On the expectation that NVGs would influence spatial cognition (i.e., way finding and the acquisition of spatial knowledge), he formulated two hypotheses: Acquisition, SpatialKnowledge. The procedure of the experiment includes adjustment and focusing, NVG training, Target search and way-finding task, Survey knowledge tests.His results demonstrate that NVGs affected not only spatial navigation and way-finding performance but also the acquisition of spatial knowledge [19].

SaraleshYadav (2009) - describes the design, development, evaluation and field trial results of PNVB with replaceable objective lenses. Passive Night Vision Devices (PNVDs) are used for viewing the targets at low light levels of illumination during night. Image Intensifier (II) Tubes are used in these PNVDs for amplifying the low light level of imagery. The PNVB with replaceable objective lenses has been designed, developed and evaluated at IRDE, Dehradun. High range performance has been achieved with latest auto gated II Tube and improved design of objective and eyepiece. PNVB can be easily configured for short or long distance observation, surveillance applications like observation, vehicle driving, map reading etc. Advantages of replaceable objective are less cost as most of the cost is of II Tube and lesser weight of the system [23].

IV. Generations

NVDs have been around for more than 40 years. They are categorized by generation. Each substantial change in NVD technology establishes a new generation.

Generation 0 - The original night-vision system created by the United States Army and used in World War II and the Korean War, these NVDs use active infrared. This means that a projection unit, called an IR Illuminator, is attached to the NVD. The unit projects a beam of near-infrared light, similar to the beam of a normal flashlight. Invisible to the naked eye, this beam reflects off objects and bounces back to the lens of the NVD. These systems use an anode in conjunction with the cathode to accelerate the electrons. The problem with that approach is that the acceleration of the electrons distorts the image and greatly decreases the life of the tube. Another major problem with this technology in its original military use was that it was quickly duplicated by hostile nations, which allowed enemy soldiers to use their own NVDs to see the infrared beam projected by the device.

Generation 1 - The next generation of NVDs moved away from active infrared, using passive infrared instead. Once dubbed Starlight by the U.S. Army, these NVDs use ambient light provided by the moon and stars to augment the normal amounts of reflected infrared in the environment. This means that they did not require a source of projected infrared light. This also means that they do not work very well on cloudy or moonless nights. Generation-1 NVDs use the same image-intensifier tube technology as Generation 0, with both cathode and anode, so image distortion and short tube life are still a problem.

Generation 2 - Major improvements in imageintensifier tubes resulted in Generation-2 NVDs. They offer improved resolution and performance over Generation-1 devices, and are considerably more reliable. The biggest gain in Generation 2 is the ability to see in extremely low light conditions, such as a moonless night. This increased sensitivity is due to the addition of the micro channel plate to the image-intensifier tube. Since the MCP actually increases the number of electrons instead of just accelerating the original ones, the images are significantly less distorted and brighter than earlier-generation NVDs.

Generation 3 - Generation 3 is currently used by the U.S. military. While there are no substantial changes in the underlying technology from Generation 2, these NVDs have even better resolution and sensitivity. This is because the photo cathode is made using gallium arsenide, which is very efficient at converting photons to electrons. Additionally, the MCP is coated with an iron barrier, which dramatically increases the life of the tube.

Generation 4 – It is generally known as "filmless and gated" technology shows significant overall improvement in both low- and high-level light environments. The removal of the ion barrier from the MCP that was added in Generation 3 technology reduces the background noise and thereby enhances the signal to noise ratio. Removing the ion film actually allows more electrons to reach the amplification stage so that the images are significantly less distorted and brighter. The addition of an automatic gated power supply system allows the photocathode voltage to switch on and off rapidly, thereby enabling the NVD to respond to a fluctuation in lighting conditions in an instant. This capability is a critical advance in NVD systems, in that it allows the NVD user to quickly move from high-light to low-light (or from low-light to high-light) environments without any halting effects. For example, consider the ubiquitous movie scene where an agent using night vision goggles is “sightless” when someone turns on a light nearby. With the new, gated power feature, the change in lighting wouldn’t have the same impact; the improved NVD would respond immediately to the lighting change. Many of the so-called "bargain" night-vision scopes use Generation-0 or Generation-1 technology, and may be disappointing if you expect the sensitivity of the devices used by professionals. Generation-2, Generation-3 and Generation 4 NVDs are typically expensive to purchase, but they will last if properly cared for. Also, any NVD can benefit from the use of an IR Illuminator in very dark areas where there is almost no ambient light to collect.

A cool thing to note is that every single image-intensifier tube is put through rigorous tests to see if it meets the requirements set forth by the military. Tubes that do are classified as MILSPEC. Tubes that fail to meet military requirements in even a single category are classified as COMSPEC [9].

Generations	Description
Generation 0	In 1950's
	Based on Image Conversion, Require source of Invisible Infrared to illuminate the target.
Generation 1	In 1960's
	Based on image intensifier, Larger and heavier systems.
Generation 2	In 1970's
	Micro Channel Plate (MCP) electron multiplier, Development of hand held and helmet mounted goggles.
Generation 3	In early 1980's
	Gallium Arsenide photocathode and ion-barrier film on MCP.
Generation 4	In 2000's
	Automatic gated power supply system is added.

Table 1 Generations of Night Vision Technique. Source: RupeshP.Raghatate (2013) [26].

V. Conclusion

The various Night Vision technologies, devices, and generations were identified and analyzed using publications from 1950s to 2000s. Night vision is a fully matured technology that has found mass applications in military, security,wild life protection and defense sectors. Proper understanding and evaluation of NVDs is a complicated task as many details are to be taken into account.

Electro optical surveillance technology is the oldest mature one among the technology of image intensifier tubes in Night Vision. It is still in a growing phase in spite of the strong competition from thermal imagers, visible/NIR cameras and digital night vision.

A long series of NVDs are availablein the international market in different design configurations, type of image intensifier tube, type of night vision optics, and performance. This review of night vision technology can help readers to understand the existingscenarioof nightvisiontechnologiesand devices.However, reading fliteratureon characterization and testing of night vision devices and analysis of dynamic situation in trends of night vision technology is recommended as a supplement to this paper.

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