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IR technology in marine applications

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Abstract

The infra-red radiation was discovered in 1800 by English astronomer Sir Wiliam Hirchel but practical applications could be dated to the beginning of XX century. First advanced scientific investigations, as well as works relating to the military applications of IR technique were carried out during the First World War. Many applications of IR radiation exist until now. It is generally accepted that taking into account the destination the devices of IR techniques can be divided on three main groups: measuring devices, observation and automatic recognition systems. Devices of this type can be found both in Navy and civil marine.

Introduction

The infra-red radiation was discovered in 1800 by English astronomer Sir Wiliam Hirchel but practical applications can be dated to the beginning of XX century [1]. First advanced scientific investigations, as well as works relating to the military applications of IR technique were carried out during the First World War. Many applications of IR radiation exist until now.

There are different segmentations of infrared radiation on sub-ranges in literature [2]. The conventional segmentation of spectral band of infrared radiation mostly applies four ranges. First range (near infrared NIR) is limited from 0.7 μm to 1.1 μm length of waves and it is dominated by returned radiation of sun. The systems of low-light-level television (L3TV) and image amplifiers and night vision systems work in this range. The second range is limited from 1.1 μm to 2.5 μm length of waves and called as short-wave infrared (SWIR). Third range of middle-wave infrared (MWIR) is limited from 2.5 μm to 7.0 μm length of waves. This range is usually limited to the band of 3.0 μm to 5.0 μm, because atmosphere suppression strongly limits working range of this area. The infrared range of MWIR is mainly used to detecting and observation of objects at increased temperatures. The long-wave infrared (LWIR) is limited from 7.0 μm to 14.0 μm length of waves, but practically used is the narrower range from 8.0 μm to 12.0 μm, mainly to detecting and observation of low-temperature objects.

It is generally accepted that taking into account the destination the devices of IR techniques can be divided on three main groups: measuring devices, observation and automatic recognition systems. Devices of this type can be found both, in Navy and civil marine.

In civil marine they are mainly used in:

- navigation;
- maritime life rescue;
- maritime pollution combating.

In the Navy they are mainly used in:

- observation and recognition systems;
- rocket and missile homing systems.

Civil Marine Applications

Navigation

Maritime navigation provides safe move of a ship or yacht from one place to the other. Navigation also answers the question where floating object is at any moment (position), as well as how to avoid dangerous situations on the way and to reach target point successfully. All this comes to solution of two tasks: definition of position and lay-out of proper course [3]. There are many methods to specify the position of floating object like: satellite navigation, geo-navigation, radar navigation, pilotage, celestial navigation, radio navigation and inertial navigation. In spite of the fact that in these methods are applied more and more technically and technologically advanced devices like GPS, radar or electronic maps, a necessity still exists for direct observation of potential threats which could be found on course of a vessel (ship or yacht). The optical observation, even reinforced by the use of optical devices working in the range of visible spectrum, cannot be effective in difficult and unfavourable atmospheric conditions. Therefore, the use of observation devices working in the range of infrared spectrum (thermal cameras) is very useful at limited visible conditions.

Several examples of use of thermal cameras in navigation are presented below:

- captains can use thermal imaging cameras to help them navigate more safely at night (Fig. 1);
- an approaching “blip” on radar screen can also mean danger. Thermal imaging allows the seeing vessels on the horizon and provides decision making capabilities before it is too late;
- icebergs and floating ice can damage a vessel severely or even sink it. It will however become clearly visible thanks to thermal imaging so that the captain can take appropriate action to avoid collisions.

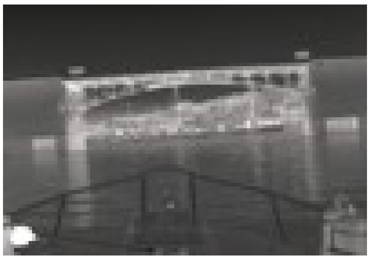

Fig. 1. Seeing at night

Maritime life rescue

Maritime life rescue of people is carried out in Poland mainly by two state institutions:

- SAR (Search and Rescue) Service;
- Navy.

SAR Service has life boats class SAR-3000, SAR-1500, R17, as well as R27 to use in operation of rescue actions. Moreover, Maritime Rescue Stations are equipped with specialist cross-country cars pulling life boats class RIB. Two multipurpose rescue vessels M/S “Kapitan Poinc” and M/S “Czesław 2” are prepared to lead rescue actions [4].

Navy possesses own rescue ships, as well as two types of multipurpose helicopters adapted to work on the sea: PZL W-3RM Anakonda and Mi-14 PS. Additionally, the Maritime Regional Units of the Border Guard are equipped with life boat class SAR-1500, which can be directed in a region of rescue actions including the sea.

The sea rescue belongs to a field of activities where the modern solutions and technical applications should be applied without delays [5]. This is connected with the need of safety assurance, as well as rescue of lives and properties. The rescue actions are very often carried in difficult atmospheric conditions and at different seasons of the year including day and night. From the other side there is very limited range and resolution of devices working in range of visible spectrum. In case of search mission of men a decisive factor of a successful operation is the time. The use of devices working in range of infrared (thermal cameras) makes possible detection of search objects in difficult and variables hydrometeorology conditions existing during rescue actions. Unfortunately, in this type of equipment are only equipped life boats class SAR 3000 (Fig. 2) and helicopters. Thermal imaging can help to quickly find a person that is floating in the water before hypothermia sets in (Fig. 3).

Fig. 2. Life boat class SAR-3000 (www.sar.gov.pl)

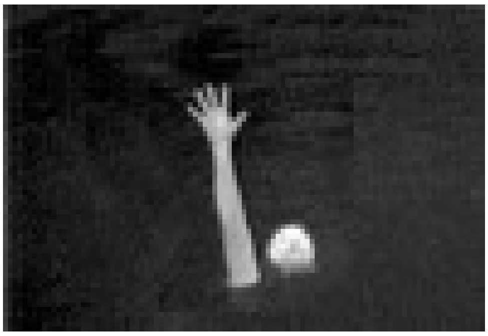

Fig. 3. Man overboard (www.flir.com [6])

Fighting the fires on vessels during rescue actions is a goal for life boats and rescue vessels also. Thermal camera is helpful in estimating the fire situation. It helps in localizing sources of fire, fighting fires hidden in unapproachable spaces and inspecting sites of the fire. It also enables to measure temperature of difficult to access elements, chimney ducts, ventilation ducts, electrical switchboards, systems, machines and devices. Knowing the temperature of an object helps to minimize the losses. The use of camera helps to perform the actions fast and efficiently at minimum extinguishing media and losses.

Maritime pollution combating

The multi-purpose rescue vessels are also designated for recovering oil pollutions and recognizing their types (mainly gases: explosive, H_2S, NH_3, CO and O_2).

A thermal imaging camera is extremely useful for detecting oil spills that are floating on the water not only in the case of an accident but also when loading or unloading fuel tankers. Oil floating on the water becomes clearly visible on a thermal image.

The stationary gas detection system is designed to detection of presence of gases in air and it is equipped with sensor of gases. Generally, it uses following sensors: electrochemical, catalytic, semiconductor and infrared.

Gases to be detected are often corrosive and reactive. With most sensor types, the sensor itself is directly exposed to the gas, often causing the sensor to drift or die prematurely. The main advantage of IR instruments is that the detector does not directly interact with the gas (or gases) to be detected. The major functional components of the analyzer are protected with optical parts. In other words, gas molecules interact only with a light beam. Only the sample cell and related components are directly exposed to the gas sample stream. These components can be treated, making them resistant to corrosion, and can be designed such that they are easily removable for maintenance or replacement. Today, many IR instruments are available for a wide variety of applications. Many of them offer simple, rugged, and reliable designs. In general, for toxic and combustible gas monitoring applications, IR instruments are among the most user's friendly and require the least amount of maintenance. There are virtually unlimited numbers of applications for which IR technology can be used. Gases whose molecules consist of two or more dissimilar atoms absorb infrared radiation in a unique manner and are detectable using infrared techniques. Infrared sensors are highly selective and offer a wide range of sensitivities, from parts per million levels to 100 percent concentrations [7].

Thermal cameras make possible detection and observation of gases in surrounding too. Thanks of infrared image it can be perceived where effluence of gas comes into being and also in which direction a cloud of gas moves. Imaging by thermal camera is the best solution for taking into consideration other methods of detecting emission of gases. Present methods and technologies depend on a punctual contact sensor that "feels" the gas in air flowing nearby of detection device. However, thermal camera displays a real image of flowing gas and it makes possible to undertake the immediate reaction and analyse the size of emitted gas.

Navy applications

Observation and recognition systems

Every floating object can be detected and identified on basis of radiation features, obtained in different ranges of electromagnetic radiation, from which the most useful are: visible, microwave and infrared.

The development of infrared technology was mainly stimulated by its military applications. First thermal camera used for military application was developed in 1952. First thermal cameras were large and heavy. The study of infrared detectors with large sensitivity and speed of reaction (InSb, Ge:Hg) made possible to obtain images with larger temperature resolutions than for first thermal detectors. The company Perkin-Elmer worked out a thermal camera for the USA Ground Forces in 1960 and Hughnes Aircraft Company and Texas Instruments made a thermal camera for the Air Force in 1965 [3]. Thermal cameras for the Navy appeared later.

The detection process in infrared band can be separated into four independent primary areas which can be characterized as follows: target to background radiation contrast, attenuation process, detection system and signal processor. Detection can take place only if target feature can be discriminated against the background. This requires (as a minimum) two criteria to be fulfilled. In the first place, the radiation contrast between target and background must generate a detector's output voltage exceeding the system noise level. Secondly, the radiation contrast must be discernible from the total observed scene.

For naval targets this approach is partly applicable. Naval targets must be found in a clutter background trough Fourier analysis or by the use of polarization type approaches. Hot exhaust gases, such as those produced by ships, show broad emission spectra with selective peaks than can be used for detection purposes [8].

The infrared signature of an object is essentially the appearance of that object to an IR sensor (Fig. 4). From the point of view of an IR camera, it is a quantitative measurement of the object's apparent infrared brightness as a function of wavelength. This is affected by many factors, including the shape and size of the object, standoff distance, atmospheric conditions, temperature and emissivity of the object, the background against which it is viewed, and the IR wavelength sensitivity of the camera.

Fig. 4. Infrared image (www.thermoanalytics.com)

On basis of a data base including infrared signatures of floating objects (ships, vessels, boats and the like) it can detect and identify these objects because their infrared signatures are characteristic for every of them (Fig. 5).

A military objective in characterizing the infrared signatures of target objects is to understand the likely infrared signature of threats and develop the means to detect them, as well as to reduce the infrared signatures of owned offensive weaponry.

Fig. 5. Infrared signature of vessel (www.sail_world.com)

The first Polish ship that had to receive optoelectronic observation system was the corvette "Gawron" (Fig. 6) but this project was given up in February 2012.

Fig. 6. Corvette of "Gawron" type (www.wyborcza.pl)

Rocket and Missile Homing Systems

Different classes of rockets and missiles have launching platforms on air, ground, sea and underwater. Marine missiles are launched from ship launchers and could be type of water-air, water-ground, water-water, water-depth and water-outer space missiles. Depth missiles are launched from submarine launcher and could be type of depth-ground, depth-depth, depth-water and depth-air missiles.

Homing in infrared (passive guidance) is one of method used in rockets and missiles. This method may be used in automatic and semi-automatic systems. Infrared camera (IR detector) located in the head of a missile (rocket) is homing this missile on a target being a source of infrared radiation.

An example of missile equipped with infrared homing system is Naval Strike Missile (NSM - Fig.7). The target selection technology provides NSM with a capacity for independent detection, recognition, and discrimination of targets at sea or on the coast. This is possible by the combination of an imaging infrared (IIR) seeker and an onboard target database. NSM is able to navigate by GPS, inertial and terrain reference systems.

Fig. 7. Naval Strike Missile (www.kongsberg.com)

In December 2008 the NSM was selected by the Polish Navy that ordered in total 50 land-based missiles (including 2 for testing) under the contracts concluded in 2008 and 2011 and delivery planned for 2013–2016 [9].

In June 2013 Poland completed the Coastal Missile Division equipped for the beginning with 12 NSM and 23 vehicles on Jelcz chassis (inc. six launchers, two TRS-15C radars, six fire control and three command vehicles) [10]. Ultimately, the Coastal Missile Division will be equipped with 48 missiles and six launchers. As it is believed Poland is going to establish second missile division in the near future.

Conclusions

Some possibilities of use of infrared technique in marine applications were presented in the paper. Their use increases the safety of navigation, possibility of people life rescue, chances of defeating threats and environmental contamination, as well as military capacities of the Polish Navy. Unfortunately, the scale of utilization of these systems in Poland is small as there is a little sale at present both, in Navy and civil marine applications.

The quicker development of infrared technology in the last years may be observed and it also creates new possibilities for using modern infrared systems in marine applications.

Infrared camuflage of different military objects and ships is a problem in which MIAT is going to be involved. The development of infrared camuflage materials and the evaluation of their effectiveness is the problem area where signatures of object and background come together. For camulage materials two conditions must be fulfilled to be effective in the thermal infrared: temperature similarity and spatial similarity. Models and measurements to test prototype camuflage materials and to optimize their performance are planned to be used in MIAT in future works.

References

1. MINKINA W.: Pomiary termowizyjne – przyrządy i metody. Wydawnictwa Politechniki Częstochowskiej, Częstochowa 2004.
2. ŚWIDERSKI W.: Metody termograficzne w nieniszczących badaniach materiałów kompozytowych do zastosowań specjalnych. Monografia habilitacyjna, Wojskowy Instytut Techniczny Uzbrojenia, Zielonka 2010.
3. www.navipedia.pl
4. www.sar.gov.pl
5. Praca zbiorowa. Pomiary termowizyjne w praktyce. Pomiary Automatyka Kontrola, Warszawa 2004.
6. www.flir.com
7. TRENCZEK S., WOJTAS P.: Rozwój pomiaroznawstwa stosowanego od pomiarów wskaźnikowych do monitorowania i nadzorowania bezpieczeństwa. Prace Naukowe Instytutu Górnictwa Politechniki Wrocławskiej, Nr 117, 2006, 327–339.
8. JACOBS P.A.: Thermal Infrared Characterization of Ground Targets and Backgrounds. Toutorial Texts in Optical Engineering, Vol. TT26, SPIE, Washington 1996.
9. GÓRKA M.: Superrakiety w starej marynarce. Gazeta Wyborcza, Warszawa 2008.
10. www.altair.com.pl