Some aspects of using IR-cameras in Arctic navigation

A Vlasov, S Buev
Murmansk State Technical University, Murmansk, Russia
anatoly_vlasov@aspol.ru

Abstract. Navigation in Arctic waters is associated with an increased risk of collision with icebergs and other ice formations. For people, these are severe weather conditions and low chances of survival in cold water if the vessel is abandoned. So according to some reports, a person can be alive in ice water no more than 5-8 minutes, and wearing a wetsuit does not increase this time by much. In this regard, one of the tasks of search and rescue is to reduce the time for identifying a person on the water. In addition to visual surveillance tools, this task can be solved with the help of thermal imagers. First of all, thermal imaging complexes are known to modern man as devices installed in airport terminals, which allow identifying individuals with elevated body temperature and therefore potentially infected. However, thermal imagers are increasingly being used for other professional and domestic purposes. This is largely due to a decrease in the cost of such devices, a reduction in size and an improvement in their usability. The idea of detecting people in the dark with a thermal imager is not new, but the method proposed in this article is original. Life jackets and wetsuits must be equipped with devices that emit infrared waves that can be captured by thermal imagers when the body temperature is not very different from the surface temperature of the water. Also, infrared cameras can be used to find pollution at sea.

1. IR-cameras in ship navigation

Maritime navigation in Arctic waters is associated with the danger of collision with ice formations (nesyak, iceberg, hummock). At the same time, radar devices can hardly detect such objects due to interference and problems with signal reflection.

Given that the conditions of the "polar night" remain in the Arctic for about six months, it is necessary to improve the instruments on the navigation bridge to help the skipper. Despite the fact that a lot of time has passed since the most tragic collision in the history of navigation with the ice of the Titanic liner, the danger of such accidents remains today.

Due to the complexity of navigation in the Arctic and Antarctic regions, the Polar Code has established additional requirements for navigational equipment for a marine vessel (independent echo sounder, non-magnetic heading aid, GNSS compass and others).

Also, with the purpose of determining ice, the Polar Code establishes the requirement to equip a marine vessel that travels in "high" latitudes, devices for the visual detection of ice, or spotlights that can be remotely controlled.

Modern thermal imaging complexes can help skippers in detecting ice formations at night, in conditions of glare from the sun and in bad weather conditions. This information is obtained by processing electromagnetic radiation of ice, and due to the high emissivity (emissivity of ice formations $\varepsilon = 0.97$), it is well identified on the thermogram (Fig. 1).
Figure 1. Navigation information obtained using a thermal imager (thermogram)

Thermogram processing programs allow you to obtain additional information about the detected ice object: temperature at various points (Fig. 2), as well as display an image in various display options (Fig. 3).

Figure 2. Definition of the area on the thermogram for analysis - on the left, distribution histogram

Figure 3. Various types of thermograms output to the operator’s screen, “gray effect” on the left, “warm” effect on the right
So from the distribution histogram we obtain information about the prevailing temperature of ice formation: -0.2 °C. The option to display images in the “gray” and “warm” effects allows you to additionally make sure that the ice is located at the course of the marine vessel.

2. Using a thermal imager during search and rescue operations
When conducting search and rescue operations, along with other means of detection, a thermal imager can be used. However, wetsuits due to thermal insulation are poorly identified, since there is virtually no difference between the temperature of a person in a suit and the temperature of water.

Figure 4 shows a photograph and a thermogram of a liferaft. One person in a wetsuit is inside the raft, and the second is directly in the water. With the help of a thermal imager, we can determine the location of people, and as it is clearly visible on the thermogram, only open areas of the human body are subject to identification, and the thermal radiation of the wetsuit coincides with the radiation of water, and does not allow distinguishing one from the other.

![Figure 4. Photograph (left) and thermogram (right) of the liferaft](image)

In Figure 5, we see a person on the surface of the water in a wetsuit. On a thermogram, only a person's face can be identified. It should be noted that the survey was carried out in a thermal room. Obviously, when a person was in real cold water conditions, the temperature of the face would drop significantly over time, which would minimize the difference in color gamut on the thermogram and make it impossible to detect a person in water using an infrared camera.

![Figure 5. Photograph and thermogram (on the right in the figure) of a man dressed in a wetsuit and in the water](image)
At the same time, in the air, we can determine both a person in a wetsuit and a person in ordinary clothes (Figure 6).

![Figure 6. The person in the immersion suit before entering the water](image)

To obtain infrared radiation from a wetsuit or liferaft, it is proposed to equip them with heating elements or special materials with a high emissivity (Fig. 7).

![Figure 7. Heating devices mounted on immersion suits for identification using thermal imaging cameras.](image)

Numerous marine tragedies show that search and rescue operations are not performed at night. In the case of the equipment of life-saving appliances by the proposed devices for detecting them with a thermal imager, the search for people could be continued at night.

3. **Using a thermal imager to search for pollution at sea**

One of the sources of pollution of the oceans is oil waste from ships. Oil stains in water can be identified due to temperature differences. So in fig. 8 sea ice pollution is well defined in the thermogram. The spot temperature is 4.0 °C higher than the rest of the ice. So the temperature at the point M1 = 3 °C, at the point M2 = -0.9 °C, at the point M3 = 6 °C.
Figure 8. Thermogram of an ice object with an oil spill on it (left), a photograph of ice (right)

4. Conclusion
Given the increased requirements for navigation equipment imposed by the International Maritime Organization in the Polar Code, marine vessels can be additionally equipped with thermal imaging complexes for ice detection.

So we can apply IR-cameras to search and rescue if the vessel is abandoned. At the same time, it is proposed to supplement wetsuits with materials with a high emissivity, to increase the likelihood of a person being detected.

Devices based on registration of infrared radiation also allow detecting oil stains on ice.

References
[1] Vlasov A 2006 Models and methods of thermographic diagnostics for energy facilities (Moscow: Kolos)
[2] Vlasov A Buev S 2016 Some questions of control of ship in a sea port Vestnik of Astrakhan State Technical University 3 107-112
[3] Vlasov A Buev S 2013 Evaluation of reliability indicators of ship electrical equipment, their impact on the safety of navigation and the probability of insurance risks Bulletin of the Murmansk State Technical University 16(4) 672-680
[4] Vlasov A Buev S 2010 Assessment of the technical condition of the electrical equipment of ships and coastal infrastructure by thermal imaging diagnostics Scientific problems of transport in Siberia and the Far East
[5] Vlasov A 2002 Analysis of the results of statistical processing of thermal imaging control data Bulletin of the Murmansk State Technical University 5(2) 155-160
[6] Vlasov A 2003 The study of non-stationary thermal processes in a dielectric using a thermal imager Bulletin of the Murmansk State Technical University 1(6) 29-34
[7] Vlasov A Buev S 2013 S Reliability analysis of electrical equipment of fishing vessels of the North-West Bulletin of the Murmansk State Technical University 4(16) 663-671
[8] Vlasov A Buev S 2013 Assessment of reliability indicators of ship electrical equipment, their impact on the safety of navigation and the likelihood of insurance risks Bulletin of the Murmansk State Technical University 4(16) 672-680
[9] Vlasov A 2008 Investigation of insulation of marine electrical machines during operation and ship repair Bulletin of the Murmansk State Technical University 3(11) 475-482
[10] Eremin M Menshikov V 2006 Reliability of monitoring the safety state of navigation with an unnecessary number of parameters Bulletin of the Murmansk State Technical University 9(2) 281-285