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METHODS OF CONDUCTING THE SHIPWRECKED PEOPLE SEARCH AT SEA WITH THE ANALYSIS OF THERMAL IMAGES AND SPECTRUM CHARACTERISTICS OF OBJECTS

ABSTRACT

Methods of acquisition, data processing and their interpretation are the main problems in the field of scanning. One of many ways and possibilities for information acquisition is utilisation of devices working in the infrared radiation range. It gains special meaning under conditions of limited visibility in the range of classical optics application.

INTRODUCTION

Shipwrecked people search on the surface of sea is a special kind of usage of infrared radiation and image information analysis. The basic method of interpretation of the visible image obtained on the output of the infrared device, is its analysis and subjective situation assessment conducted by the system operator.

Due to very diverse character of objects in bearing of: kind and size of radiation surface, emission proprieties, temperature and specific proprieties of a background, conducting the analysis and interpretation of image data are very consuming and difficult. However, discrimination of a man or a life raft type object on a sea surface, by an experienced operator, in most cases is possible.

Projects concerning optimal usage of devices working in infrared range for sea rescue have been carried out in the Polish Naval Academy.

Data from observation of assigned water reservoir obtained in the range of infrared radiation are presented in the form of visible images. They represent the distribution of temperature on the scanned surface. Proportional value of visible image signal brightness to the power density of registered radiation in the infrared range is the basic principle of thermal cameras operation. In the visualisation device (monitor + graphic card) the power of radiation is represented by the brightness value - for the RGB system or degrees in the grey scale for black and white images.

The basis for a visible image rendering is analysis and subjective assessment carried out by the system operator. The analysis of gained visualisation can be

accomplished, in many modern systems - in the real time by using the system software or after recording - on any device for image analysis.
The efficiency of detection and identification of an examined object depends, in such circumstances, on:

- quality of gained image;
- capabilities of analysis and criteria of data rendering;
- monitor resolution;
- operator experience and perception capability.

To carry out the optimal analysis, the gained image should comprise many distinguishable scenery elements and should be characterised by a large brightness contrast. Acquisition and analysis of information coded in a scene element should follow some specified procedures to elaborate the constant reference level for results rendering.

In the paper, the analysis of infrared images with the Agema 900LW-software system is presented.

DESCRIPTION AND METHOD ASSUMPTION

The starting point for the proposed method was execution of a series of observation character measurements, where special attention was paid to the observation ranges of chosen objects, direction features and radiation property, with regard to object positioning in relation to the observation station. It was found, for example, that in a case of vertical position of a man in the water, what is conditioned by the type of lifesaving equipment (e.g. life-jacket), the best visible part of the body, in infrared range, is the head of the 'castaway', located usually above the water. At the same time, the face is the surface of the head with the highest radiation emission.

For the assumed system of object - measurement station, where the object's position is fixed and measurement range, meteorological conditions, background temperature (water) are known, the emittance values of a man for two measurements distances were calculated.

The situational draft for the measurements is depicted in Fig. 1.

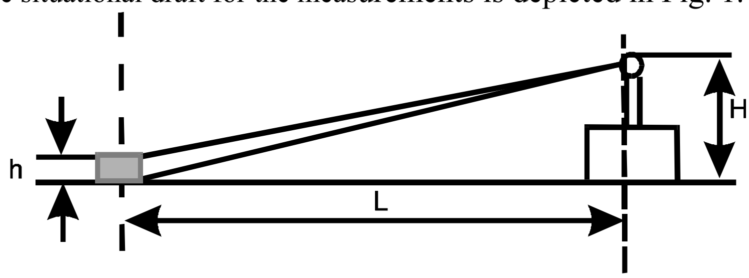

Fig. 1. Visual situation for the measurements character designation
H - altitude of the measurement station [3 m];
L - measurement distance [L_1=50, L_2=615 m];
h - altitude of the object [approx. 30 cm].

ANALYSIS OF AN IMAGE FOR CHOSEN OBSERVATION SECTION S_X

For an image having optimal contrast and brightness, we assign a working area (e.g. AR01) equal to the area of the scene. With a help of an image analysis program, we carry out computation of the extreme end statistic values and we determine the temperature histogram in AR01 area. The results of computations are depicted in the form of RESULTS table and HISTOGRAM - temperature histogram. On the basis of the histogram and the results table we determine the proportional distribution of temperatures in the area, and on that base we can conclude which areas are the background of the scene and which element can potentially be searched object. The processes of objects' search and identification under described measurement conditions take place according to the following procedure.

We add two auxiliary measurement lines to the image: L01 - horizontal, and L02 vertical. Change of position of the lines in directions X and Y of AR01 area plane facilitates the analysis of the area along these lines, with better precision than for the area alone. The results are depicted as the table of extreme and statistic values, and as graphical temperature profile. In case of father analysis with the method, the system facilitates conducting the computations at any point on the measurement line or aside from it.

OBSERVATION OF CHOSEN SECTOR IN THE OBJECT'S SEARCH AREA

The view of scanner lens and the measurement station position define the observation sector. Thus, the observation range is limited and it depends on the size of the object being searched (the height of silhouette over the sea level in the direction of observation).

The scanned image of scene comprises information from all the objects and the background of the scene, therefore, in the first stage of search, the signal of the highest temperature should be analysed. There is possibility to determine the position of the object for the fixed view.

S_1	S_2
S_x	S_n

Fig.2. Exemplary division of view area for scan detailed analysis
$S_{1.....}S_n$ - observation sectors in designated area
S_x - sector selected for further analysis.

SELECTING THE SCENE SPECIFIC ELEMENTS

For a case of selecting the scene specific element which can virtually be the object being searched, we introduce the next AR02 working area - being simultaneously the silhouette of designated object. For AR02 area, we put in the data for the detailed analysis. Talking the tabular value of the emission factor for the searched object (e.g. for men body), the measured air and water temperatures - as a reference temperature (background), the air humidity and approximated or measured measurement distance.

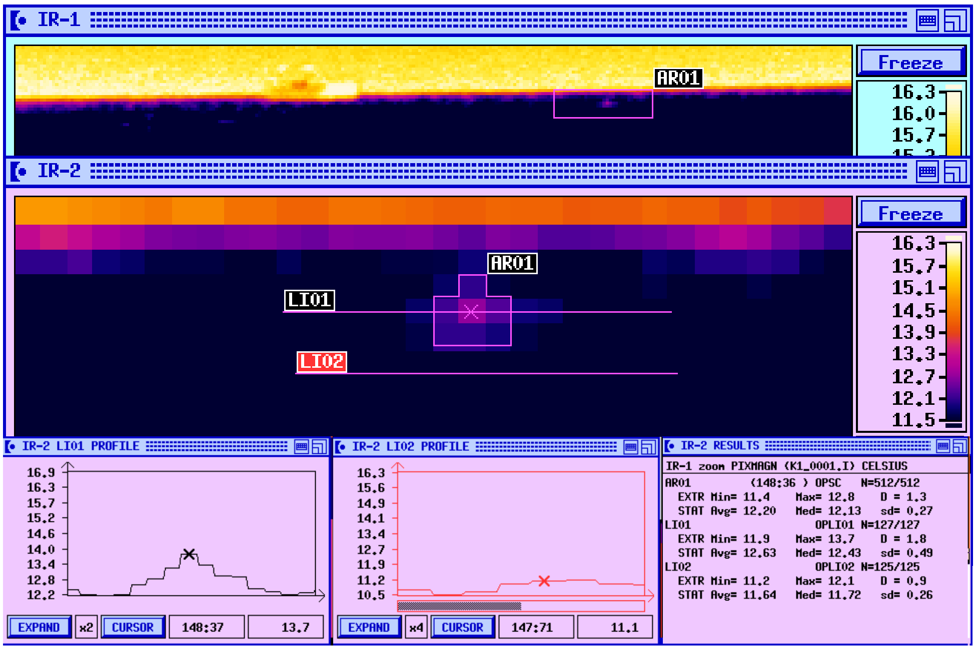

Fig.3. Thermal image of a life raft with separated AR01 area and the two auxiliary lines L01 and L02 for carrying out the image analysis with window results

In our bearing of surveillance, there is possibility of defining the spectral emittance of the object. It is tied to calculation of the radiation power density distribution for the object in a specified direction, in function of radiation wavelength. The emittance calculations of the object are carried out for fixed measurement conditions.

In the projects that have been carried out in the Polish Naval Academy, the possibility of calculation and application of the spectral emittance is being considered as one of the distinctive features of the object in the searching and discriminating processes.

The computational tools of the AGEMA900 system allow for computation of a spectral emission of an object with the help of RADIANCE CONTROL, the image analysis program.

The temperature of the object is the input argument for the program. To determine a characteristic curve in the experiment, it was assumed to use the object's temperature calculated by the system. Programs from the image analysis pack allow calculation of a temperature for a point or the whole area. The system allows dividing the spectrum range of scanner with the step of 0,1 μm, and that was applied in computations. The calculations is carried out as in (1):

$$E_C = \int_{8\,\mu m}^{12\,\mu m} E(\lambda)\,d\lambda \tag{1}$$

where: E_C - object's emittance,
E (λ) - monochromatic emittance (for tabulator emissivity factor in orthogonal direction to the emitting surface).

Emittance can be determined from Stafan-Boltzmann formula, where the relation of the emittance to the temperature of the object and the surface emissivity factor is defined.

$$E_{c\lambda} = \varepsilon_\lambda \delta T^4 \tag{2}$$

where: $E_{c\lambda}$ – total emisive power a body ;
δ – Stefan- Boltzmann constant = $5{,}7 \times 10^{-8}$ [Watts/m^2];
ε_λ – emissivitty factor (the ratio of spectral radiant power from an object to that from a blackbody at the same temperature and wavelenght).

This states that the total emissive power of a body is the same from a blackbody at the same temperature reduced in proportion to the value of ε_λ from a body.

Expressed mathematically, this can be written as the ratio of the spectral emittance of the object to that of a blackbody as follows:

$$\varepsilon_\lambda = \frac{E_{\lambda 0}}{E_{\lambda b}} \tag{3}$$

where: $E_{\lambda 0}$ – total emissive power of a body;
$E_{\lambda 0}$ – total emissive power of a blackbody.

Generally speaking, there are three types of radiation source, distinguished by the ways in which the spectral emittance of each varies with wavelenght:

1. a blackbody, for which ε =1;
2. a greybody, for which ε = constant less then 1;
3. a selective radiator, for which a varies with wavelenght.

The emission factors for two surfaces were taken after the tabular values provided by the equipment producer.

Table 1. The emission factors for searched objects

Type of object	* Emissivity factor ε
Man	0,98
Pontoon (Black rubber)	0,95
Sea water	0,96

* Agema Infrared Systens: User's Manual, Introduction to the Theory of Thermography, Dec.1993 r.

The emittance of the object can be determined in two ways:

1. When the emissivitty factor and the object's temperature are known, then from (2);
2. Summing the values of monochromatic emittance over the whole spectrum range of scanner, from (1).

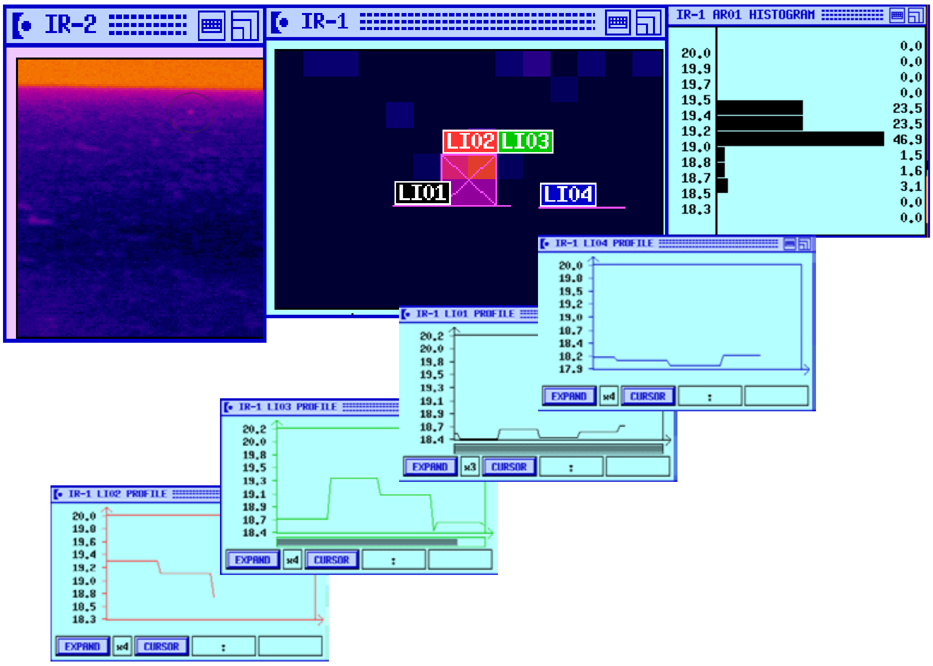

Fig. 4. Thermal image depicting a man in the water, in a life jacket, from the distance of 615 m, with the graphical analysis of thermal images for assigned measurement lines and area:
LI01 - defined on the joins of the object's edge and surface of the water,
LI02 - defined at the place of detection of a virtual searched object,
LI03 - defined on the diagonal of the object's silhouette,
LI04 - defined on the surface of water - image background,
AR01 - the temperature histogram in the area set by the silhouette of the object.

Table 2. Measurement conditions

Measurment Distance	Atmospheric temperature	Water temperature	Sea state*	Direction and description of wind**	Visibility
L_1= 50m. L_2= 615m.	17 ^oC	10 ^oC	3	230/ 2	Poor (5km)

* Douglas sea scale

** Beaufort scale

The values of emissivitty factor for human skin and seawater were taken after table values (Tab. 1). Measurement distance was taken with ŁPR1 laser range finder.

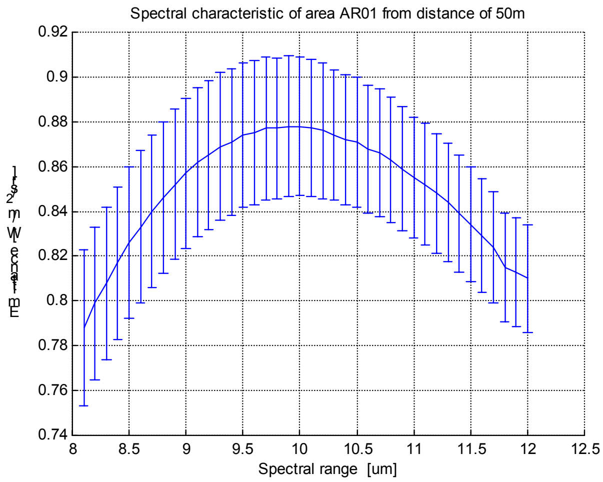

Fig. 5. Spectral emittance of a man in the direction of observation process measurement distance L_1=50 m.

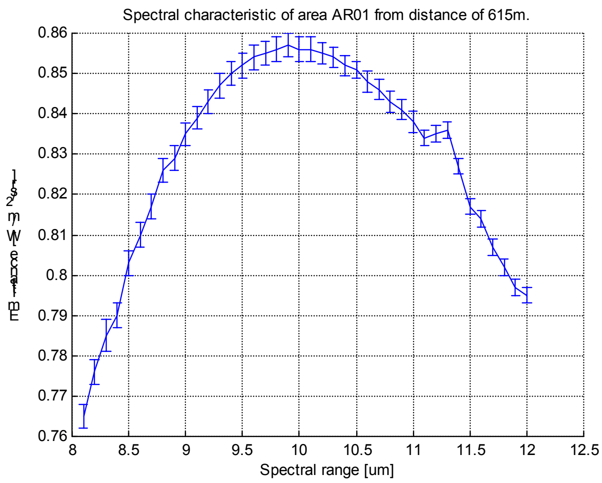

Fig. 6. Spectral emittance of a life raft in the direction of observation process measurement distance 615 m (AR0l area window IR2, Fig.4.)

CONCLUSIONS

The primary penetration method of assigned search area, with the usage of infrared image devices, is subjective assessment of luminance contrast of individual scene image elements. Because luminance contrast relates directly to the difference between the searched object temperature and the background temperature, so to a great extent, for the assumed station model, thus the discrimination of shipwrecked person on the sea background depends on an observer's capacity - system operator.

On the experiment measurement station, the images for a real object, a man, were obtained with the usage of Agema 900LW thermovision system. Obtained results allow conclude about usability of chosen system features (functions) for conducting the thermograph analysis in bearing of discrimination of virtual shipwrecked person on sea surface.

Conducted analysis of the problem and obtained results, give the general idea on virtual usability of infrared systems in the sea rescue units activities. *Ipso facto*, anticipated is an increase in efficiency of these activities, and first of all, in the process of shipwrecked people search.

REFERENCES

1. Agema Infrared Systems: Thermovision 900 Series, User Manual, Parts 1 and 2, 1993.