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THE METHOD OF THE QUICK IDENTIFICATION OF POLLUTION DERIVED FROM OIL ON THE SEA SURFACE

ABSTRACT

The topic of the publication is the description of the method of quick detection and identification of pollution derived from oil on the water surface. This method is based on the teledetection technique. It is based on the application of a teledetection head, which consists of a digital camera working in a 300 – 1100 nm range and equipped in a suitable filter. The point is to receive digital imageries in several spectral ranges, and processing them in such a way to get an appearance of a polluted area on the imagery. It is possible because of using different reemission characteristics of polluted water surface and water surface free from pollution.

Keywords:
oil pollution.

INTRODUCTION

Pollution derived from oil causes the forming of oil films on a sea surface, which, depending on a size and environmental conditions, can last there from several hours till several weeks. According to analyses of observable ness of pollution of this type there was established the row of practical relations between visual effects on surface of oil-polluted sea area and its thickness, kind of oil and current conditions on sea surface. For a number of years there has been used scanners working in infrared range (scanners IR). The working in range of infrared scanners for many years have already been practiced (scanners IR). They use the electromagnetic radiation in the range of the wavelength = 8 – 12 μm spectrum. The principle of working of these devices uses the fact that there is different temperature on the surface of oil-area than on area of pure water. Therefore, with regard to difference between the emissivity of oil (0,94 – 0,97) and water (0,98), the oil becomes visible. The sample image produced as a result of processing signal of scanner IR can be seen in fig. 1. The minimum thickness of the oil layer, which can be recorded is placed in the frames from 10 to 70 μm [1].

The disadvantage of the method, apart from the impossibility of recording of film-areas below the thickness 10 μm, there is a partial correlation between thickness of the layer of oil and contrast of image. In this method there is no possibility of recording the existing emulsified forms of oil. That is why the attempts of use in infrared technique shorter spectral range wave 3 – 5 μm are made, in which spectrum IR manifests complex structure and delivers more pieces of information about the radiating substance rather than in far infrared.

Similar tests, so far only in a laboratory, are conducted in the range of very near infrared radiation – below 2,5 μm. [2].

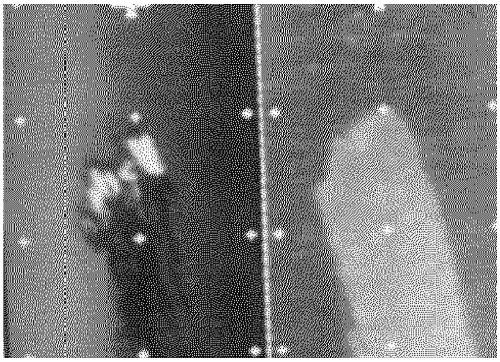

Fig. 1. The example of images of the same oil stain based at the signal of scanner IR

Simultaneously with IR techniques, the using of the range of ultraviolet techniques (scanners UV) was begun. The principle of the working of these detectors is using oil characteristics is consisting in ability to reflect in ultraviolet the part of electromagnetic spectrum considerably stronger than the surface of water. Using this technique there can be observed the film-areas of thickness even below 10 nm [3].

The combination of the methods IR and UV considerably facilitates the detection of oil pollution, but only in a day time.

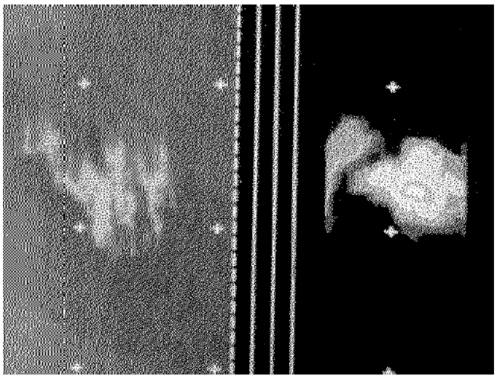

Fig. 2. The example of images of the same oil stain based on the signal of scanner UV (on the left) and microradiometer (on the right)

TELEDETECTION MONITORING HEAD

Till now the teledetection methods has been used mainly in reference to air – ceiling and satellite, it means to large surface areas. There is lack of use of this type of applications for the smaller areas, e.g. wet docks, where oil pollution appears too and is not less dangerous for environment. According to authors, this kind of methods can be used in objects of this type.

Therefore the conception of proposing the pollution environment monitoring system for small areas was introduced, where the risk of contamination is not smaller than in an open sea.

Currently the conception of such a system has been worked out and the analysis of possibility of its creation has been conducted as well as the basic researches of possibilities of its use were executed. The elaborated conception assumes the creation of monitoring system which works in support of teledetection head as well as the unit processing the image data.

Preliminary analyses have proved that the most profitable, from the point of both technical and economic view, will be the monitoring connected with a teledetection technique in range about 300 – 1100 nm. The teledetection head can be made in two variants:

Variant 1. The set of monochromatic cameras supplemented with the RGB camera. Monochromatic cameras work in range 300 – 1100 nm and are equipped in narrow-band filter, however the camera RGB works in the whole accessible range and serves the monitoring of the observed stages.

The cameras in that system are synchronized and justified so they can observe the same area block simultaneously. The applied filters cause that the image is received in several spectral ranges simultaneously. The kind and ranges of individual filters are chosen for the specific kind of pollution.

Gained in this way images are passed on to the central processing unit, processed and displayed.

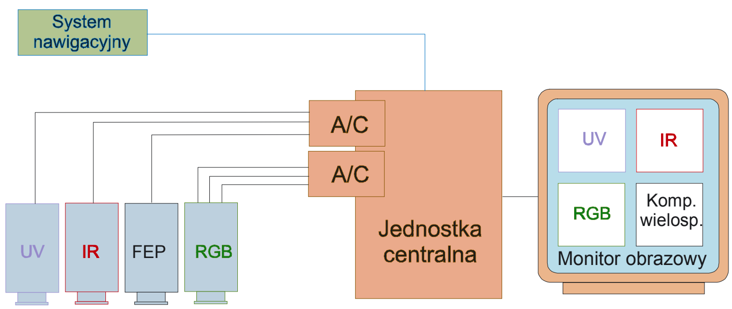

Fig. 3. Functional diagram of camera system with filters

Because of receiving the picture of the same area at the same time we have already the possibility of making operation on the images at the moment of projection (real-time). It is possible to make arithmetic or logical operations causing that the result of their work will be displayed in conventional colours, where individual colours will be assigned to the suitable surfaces.

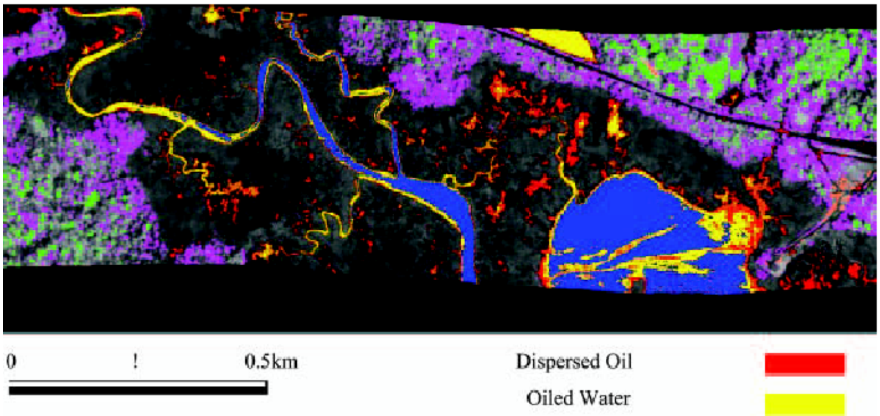

Fig. 4. The example of the image in conventional colours

Variant 2. The one monochromatic camera equipped in tunable filter. This is a hyperspectral system.

It permits to get images in very narrow frames of electromagnetic spectrum, even down to 0,01 nm. Gaining such images makes it possible to follow-up very subtle changes of observed surfaces. A several ranges can be chosen, in which the contamination with definite substances is most visible.

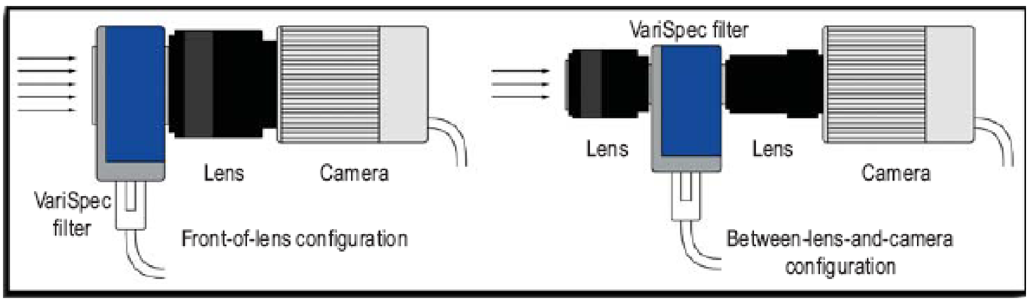

Fig. 5. The example of the hyperspectral system

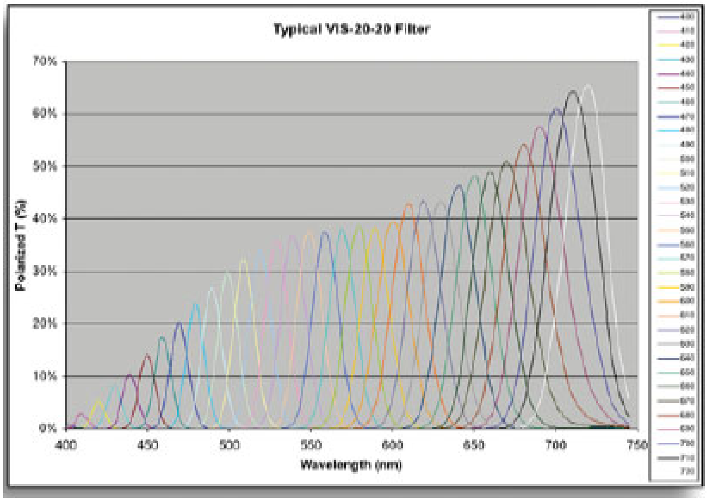

Fig. 6. Ranges of the work of tunable filter

Such an arrangement is more universal than the one introduced in variant 1. It also permits to choose optimum ranges automatically. However, it is more expensive solution.

Because of the parameters of optical camera system as well as the area that has to monitored, there is the necessity of the installation of band heads on the rotary platforms. It will allow the scanning of an area by each set, and in case of detection any contaminated area, following changes precisely and detailed location of the area.

HYPERSPECTRAL DATA PROCESSING

Very narrow spectral ranges in both 1 and 2 variants are used to observe the marked area. The processing of such images requires consideration of interaction of electromagnetic radiation with the studied surface. On the surface the energy can be reflected, absorbed or/and transmitted, where a percentagle participation depends on coefficients: reflection, absorption, transmission. According to Wien's Law the power of radiation power depends on wavelength and temperature of the surface. In accordance with this rule the maximum of power radiations moves towards the shorter electromagnetic waves side. It has the principle meaning for analysis of teledetection data.

In the case of shorter waves (300 – 2500 nm) the main part has the solar radiation, but in the case of the longer range the Earth begins to take part in the radiation being recorded by detector.

Therefore visible channels and near infrared radiation can also be treated classically and such images are treated as reflectivity coefficients. The hyperspectral data processing depends on the analysis of reflectivity/emission coefficient from wavelength. It means that preliminary processing of hyperspectral data to reflectivity/emission coefficient value is necessary [4].

Hyperspectral images, just like multispectral, consist of images recorded in different fragments of spectrum. The difference is that in case of hyper spectral images we have to deal with definitely larger quantity of channels (from tens to a few hundred). Individual channels are more considerably densely disposed and contain small fragments of electromagnetic spectra (10 – 20 nm). The idea of hyperspectral imageries is as follows. The more channels we will record the more possibilities of detecting the differences of spectral reflection of objects studied by us we will have. At the same time we will approach more and more to the shape real spectral curves of these objects. If we were able to record properly enough of narrow fragments of spectra we would recognize the objects by comparison of recorded spectral answers with spectral curves gained from spectrometers measurements. Such curves are published in so-called spectral libraries [3].

In order to process and interpret correctly this type of images data, it is necessary to conduct spectrometric measurements of studied surfaces. This kind of tests depend on determination and normalization the reflections characteristics of studied objects.

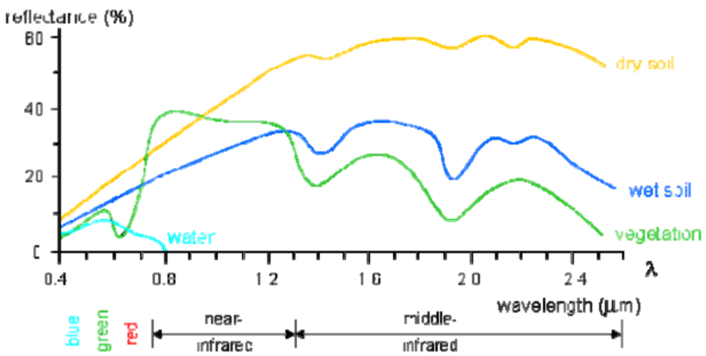

Fig. 7. The examples of reflections characteristics of different substances

As we can see in fig. 7 already in visible range (400 – 800 nm) are detectable differences of different substances in reflectivitie coefficients. The use of hyper spectral technology for this range allows to catch subtle differences for individual objects.

Preliminary researches proved that such selection of ranges from this frame is possible, where pollution derived from oil contaminations are well visible on gained images.

The described method states the following stages of conduct:

– researching of reflections characteristics of oil-films on the surface of water in different light conditions and different states of water;
– creating of reflections characteristics libraries;
– the choice of hyperspectral bands, the most profitable from the point of view of detections the polluted areas with derived from oil substances (variant 2);
– the selection of filters to cameras in teledetection head (variant 1).

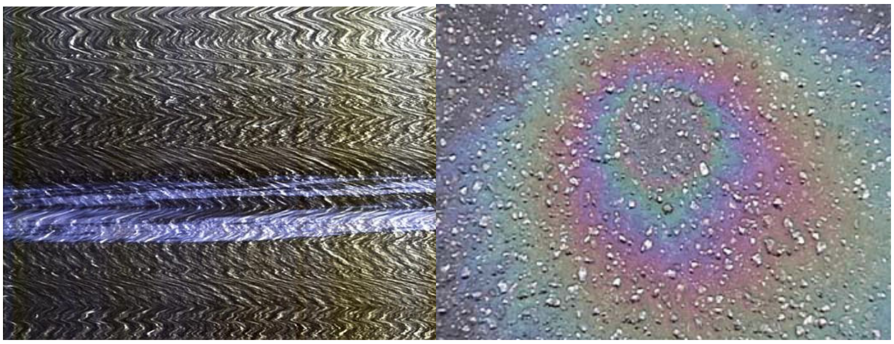

Fig. 7. View of oil trail in narrow segments of spectrum of visible range

Preliminary researches of images recorded with narrow band interference filters, permitted on choice of several sub-ranges in which polluted areas are well visible. For images gained in these ranges there was applied the processing depending on:

– conducting of the operations of reducing noises;
– making the classification with the supervised methods;
– adding images after classification.

In this way there was received the image in conventional colours presenting visible polluted areas. Example of such image is presented in fig. 8.

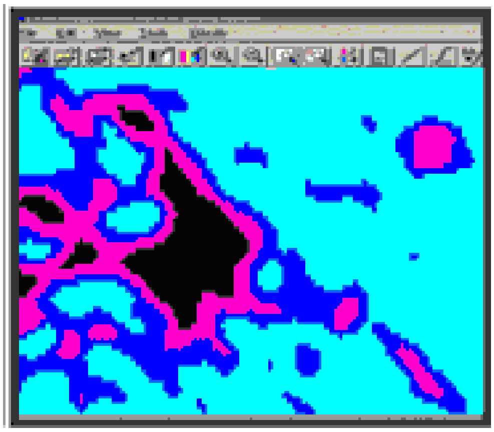

Fig. 8. The example of the image after classification process
(colours point polluted areas in different stages of contamination)

CONCLUSIONS

The described method can find the use in monitoring and quick detection of all kinds of pollution on the water surfaces. Because of using teledetection heads, it will make possible to observe docks, piers of stevedoring, trans-shipping, coastal sea areas etc. The proper distribution of teledetection heads and processing of gained images can be a supplement of existing monitor systems, which are used in this kind of objects. The additional element can be completing image with maps of chosen areas, which will permit the exact location of polluted places and the follow-up expansion of contaminations. It makes possible to gain additional information for emergency services, evaluation of possible damages and delivers additional data for making the correct decision by critical service management.

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