Pollution identification based on remote sensing from UAVs and multispectral image processing

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Introduction

This investigation is devoted to monitoring boat oil and petroleum product pollution, as well as pollution with petroleum products such as diesel fuel, on the surface of water bodies using multispectral cameras placed on quadrocopters.

The technical and scientific aspects of remote monitoring of oil spills are described in a large number of scientific papers. But the analysis of existing methods based on optical and microwave satellite remote sensing showed that the most promising methods for the rapid detection of oil pollution on the water surface are methods based on the use of UAVs.

Assignment of tasks

The method for monitoring oil pollution based on image processing of a multispectral (five-channel) camera placed on a UAV is presented. Analytical expressions for the index of spectral brightness coefficient of oil, boat oil, and diesel fuel were derived for the first time for use in the Neva geographic information system and applied to the analysis of multispectral images. Obviously, the use of expensive hyperspectral cameras can provide more accurate results, but the main goal of the authors here was to develop a simple low-cost method that allows for preliminary monitoring of surface contamination of water bodies.

Laboratory experiment

As part of the study, first of all, measurements were taken of petroleum film thicknesses 2-50 μm in the visible range using a FLAME-T-UV-VIS-ES diffraction spectrometer. Illumination was carried out with a halogen lamp, then the measurement results were normalized by solar radiation. The measurement results for a film 50 μm thick are presented in Fig. 1. In Fig. 1 shows the spectrum of fresh water (1) and petroleum (2) and in Fig.2 shows the spectrum of fresh water (1) and boat oil (2). In addition, in Fig. 1 and Fig.2 shows the central frequencies of the multispectral camera, which was later used for filming: (1) central wavelength of the “blue channel” (475 nm), (2) central wavelength of the “green channel” (560 nm), (3) central wavelength of the “red channel” (668 nm), (4) central wavelength of the “red edge” channel (717 nm), (5) central wavelength of the “infrared channel” (840 nm). Since the difference in the first channel is large, and practically absent in the fourth for both cases, the index of the spectral brightness coefficient for a petroleum film and boat oil film can be calculated as:

$$K = \frac{I_1 - I_4}{I_1 + I_4},$$

where I_i is the intensity of reflected light in the i-th channel.

When multispectral images are processing in the Neva geographic information system, this expression may be refined and complicated for more accurate identification.

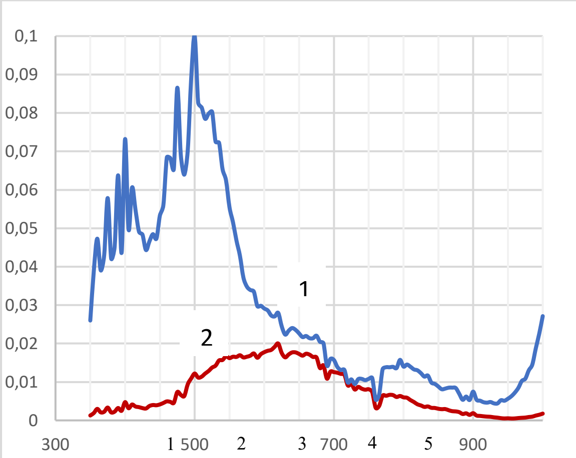

Fig.1. Spectra of light reflected from water (1) and from a petroleum film on water (2)

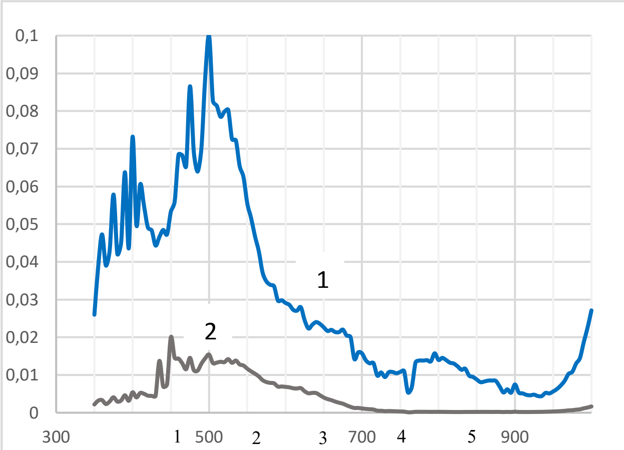

Fig.2. Spectra of light reflected from water (1) and from a boat oil on water (2)

Field studies

In field conditions, the survey was carried out in the daytime on a sunny day from a height of 50 m at a water test site with fresh water using a multispectral camera on a quadrocopter. Figure 3a shows an RGB image of the boat station. There are recently arrived boats at the station, and therefore minor pollution of the water surface around them. Figure 3b shows the results of processing a multispectral camera image in the Neva geographic information system. Here, areas of diesel contamination are marked. The spectral brightness coefficient index in places of pollution is approximately equal to –1. The image shows that the size of the spots does not exceed 1 m^2 and, obviously, they cannot be detected by other remote monitoring means. In the general case, the resolution of the method is determined only by the size of one pixel and, thus, the proposed simple technique makes it possible to determine contamination from approximately 10 cm. Figure 4a shows the RGB image of the petroleum slick on the water surface and Fig.4b shows the results of processing a multispectral image of the petroleum slick. As a result of processing in Fig. 4b, it is possible to identify petroleum slick on the water surface.

Fig. 3a. RBG-image of the boat station

Fig. 3b. Multispectral image of the boat station

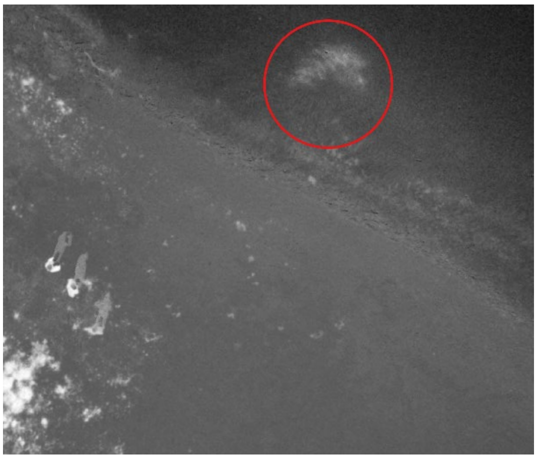

Fig. 4a RBG-image of the coastal area Fig. 3b. Multispectral image of the petroleum slick

Conclusion

A simple-to-implement method that does not require large material costs is proposed for monitoring the pollution of water surfaces with boat oil and petroleum. To develop it, laboratory measurements were carried out using a visible diffraction spectrometer and corresponding calculations were carried out. The methodology was verified during field testing. The proposed technique makes it possible to monitor water surface pollution several centimeters in size using standard multispectral cameras and the Neva geographic information system.

Our publications

1. Barabanova E.A., Vytovtov К.А., Гладких Т.Я., Мигачев А.Н. Environmental Monitoring of Water Surface Pollution in the Visible Range by Using UAVs // Journal of Communications Technology and Electronics. 2023. Vol. 68, Suppl. 3. С. S388–S392.
2. Diane S., Vytovtov K.A., Barabanova E.A. Analytical and Neural Processing of Multispectral Images for Identification of Water Pollution / Proceedings of 7th International Conference on Information, Control, and Communication Technologies (ICCT 2023).: IEEE, 2023. С. https://ieeexplore.ieee.org/document/10347031.
3. Vytovtov К.А., Barabanova E.A., Gladkikh T.Ya., Kulina A.L., Vytovtov G.K. Remote monitoring of water pollution with oil products in the visible range by using UAV multispectral camera / Proceedings of 2022 International Conference on Information, Control, and Communication Technologies (ICCT). IEEE, 2022. С. https://ieeexplore.ieee.org/document/9976826.