Exploring the use of unmanned aerial vehicles for automated oil spill identification

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Abstract. The potential use of unmanned aerial vehicles for the identification of oil spills poses a number of critical challenges related to the selection and justification of the hardware and software to be used. The purpose of this article is to analyse the technical solutions and characteristics required to enable the use of unmanned aerial vehicles in oil spill identification tasks. The author provides a comprehensive study of the issue presented, including a description of the necessary technical equipment and requirements in relation to the composition of the unmanned aerial vehicle.

1 Introduction

Unmanned aerial vehicles (UAV) are actively used for practical applications in many professional areas of human activity. However, the most important and up-to-date use of UAV has been in the oil and gas industry. Thus, UAVs solved a number of important tasks in the oil and gas sector related to the need to monitor and detect various objects. One of these tasks, which requires the use of innovative digital technology tools, is the detection and identification of oil spills. Current UAV technologies are one of the most effective solutions available today for automated oil spill identification. The technological process of solving this problem through unmanned aerial vehicles includes a number of specific stages and actions [1].

Thus, oil spill identification using drones is divided into the following main stages:

1. Providing continuous monitoring. The ability to identify oil spills quickly and effectively requires the continuous use of a team of unmanned aerial vehicles. Current UAV technology solutions have limited battery capacity and monitoring range. The important point when providing monitoring is the ability to communicate between UAV and to organise them together for the best possible coverage of a larger area. This is what defines the requirement for high-powered transceiver/receiver units on board the aircraft. The use of effective radio communications with signal amplifiers is key. Monitoring includes the continuous observation of terrain to detect anomalies. A team of UAV captures an area and sites where there is a chance of an oil spill occurring;

2. Anomaly detection. The software embedded in the UAV processor has the ability to detect anomalies. For instance, in case irregular objects are detected in the terrain, the UAV receives a signal that requires photographing the terrain for further scanning of the imagery.

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Surveillance is performed by high-resolution cameras with the ability to shoot in the infrared spectrum.

3. Image scanning and processing. Up-to-date UAV must be equipped with software that enables automatic image processing for oil spill detection. So, in the case of detection of anomalies during monitoring the area, a special software part gets the image for further detection and identification of oil spill or to reject the potential danger. It should be noted that the automatic oil spill scanning and confirmation onboard the UAV reduces the use of various resources to verify erroneous detection.

4. Confirmation of oil spill identification. As a result of image processing by the UAV software, the identified anomaly is confirmed or disproved. Special algorithms, such as dispersion reduction in order to increase the contrast of the image, allow a high degree of probability to obtain a final verdict on the detected anomaly.

5. Communication of incident information. As a result of oil spill confirmation, the drone transmits data to the security information point. It should be noted that, depending on the conditions, unconfirmed oil spill data may also be transmitted to the Security Information Point. In this case, the information will be additionally checked by a specialist, who will take the final decision [2].

This set of actions cannot be performed using standard tools and classic drones. The most important part for the possibility of oil spill identification on the basis of UAV is its hardware and software, which includes many features and requirements.

2 Materials and methods

The main requirements for the software part of the UAV are smart or direct mathematical image processing algorithms or methods. Special software solutions allowing for fast processing of the received images are required in order to improve anomaly detection and oil spill detection. As an example of conventional mathematical image processing, dispersion reduction techniques can be used to increase contrast. However, the most effective are intelligent methods of image processing based on the architecture of convolutional artificial neural networks. The implementation of this functionality is possible using appropriate hardware UAV [3].

As one of methods of intellectual image processing it is possible to use a method of Template matching. This method uses the sum of squares of differences calculated between a template and an image as its metric. Image processing, splitting and scanning is performed as a result of data flow processing in the logical complex based on artificial neural networks (convolution network).

The cross-correlation method allows for detecting anomalies and identifying oil spills in the image.

Also, the main requirement to the software part of the analyzed objects is the possibility of collective organization between a group of unmanned aerial vehicles.

It is important to note that the most suitable method of organizing UAV interaction is formation. This method results in a strictly specified position for shape conservation. This is particularly important for oil spill identification tasks in order not to miss monitoring any area of the terrain.

Based on the set of functions for the software part of the UAV, the hardware requirements for the UAV are formed. Realization of intelligent methods of image processing is possible only on the basis of appropriate technical solutions. Variant for practical realization of software tasks is COM Express module. This module is a complete computer in a compact housing on Intel Atom platform. The ICE-BT COM Express T10 module card features a quad-core processor that supports the fastest image processing. In addition, the 4 GB on-

board hard disk drive allows for high volume storage without the need for memory cleaning [4].

Several technical solutions need to be used in order to be able to capture images with sufficient resolution. The first requirement for effective terrain monitoring is a high-resolution camera (at least 640 × 512 pixels) that can capture images in the infrared spectrum. It is at this resolution that the oil spill area can be imaged more clearly and has a different temperature and emission spectrum to that of conventional objects on the ground. It should be noted that clear locations of suspected oil spills can only be captured using an infrared camera due to the possibility of detecting increased thermal radiation from the oil.

In this case, due to specific tasks of oil spill detection, which are determined by high risk for UAV, an important parameter of used camera should be the digital zoom function. It is on the basis of zooming in, not physical proximity to the spill area, that UAVs have greater protection when surveying the terrain.

The use of high performance antenna systems is also required for efficient reception and transmission of location information between UAVs. ForaAS1225 antenna including interference suppression technology and low current amplifier is the best option. In this case the small size allows you to install this solution on the UAV without loss of speed and maneuverability.

The illustration shows a dimensional diagram of the antenna.

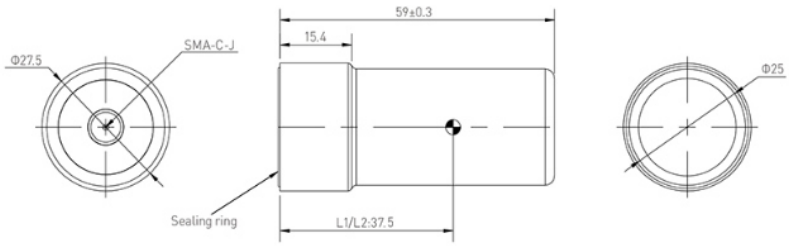

Fig. 1. Dimensions of ForaAS1225 antenna, in mm.

Therefore, it is necessary to consolidate a set of technical requirements into a single table. The table presents a complete set of hardware and software requirements for modern unmanned aerial vehicles to detect and identify oil spills quickly and efficiently.

Table 1. A set of hardware and software requirements for the UAV.

No	Technical solution	Type of hardware/software	Purpose	Requirements	Model
	Stage: "Continuous monitoring"				
1	High resolution infrared camera	Technical device	Image registration, terrain scanning for temperature differences	Minimum resolution 640x512	DJI Zenmuse XT S Keii HL-640L

2	Antennas for UAVs	Receiving and transmitting device	Communication and organisation of positioning in space with other UAVs	Frequency bands: 1800 MHz, 2.4 GHz Gain factor: 4 - 10dB	ForaAS1225 Tallysman HC871
	Stage: "Anomaly detection"				
3	Microprocessor	Hardware	Information storage and programme operations	Quad-core pro-core processor 4GB hard drive	ICE-BT COM Express T10
4	Image processing tool	Software	Photogrammetric data processing	Possibility of reducing dispersion to increase the contrast of the image	TrimbleUAS Master
	Stage: "Scanning and image processing"				
	Similar to point No. 4				
	Step: "Confirming oil spill identification"				
	Similar to point No. 4				
	Stage: "Communicating the incident"				
	Similar to point No. 2				
	General requirements				
5	A ground-based antenna	Receiving and transmitting device	Increased range of communication systems relative to standard antennas	Bandwidths: 920 MHz, 1250 MHz, 1800 MHz, 2.4 GHz Gain: 13 - 25 dB	FAR CT-HF-2LTF Mxx

3 Results

The key issue in the use of UAV is the functionality and characteristics of the vehicles. It should be noted that for oil spill identification tasks, UAVs must have the best balance between autonomy time, range from the station, and maximum flight speed. There are currently thousands of UAV models that can be used quite effectively for monitoring tasks.

Analyzing the characteristics, the Dozor-600 stands out as the obvious leader. However, the high price of the device and the complexity of technical maintenance does not confirm the rationality of using this variant. The most suitable unmanned aerial vehicle, taking into account the presented technical characteristics, is the Supercam-350.

Important engineering considerations in the use of drones include communications with the ground station. Maximum line-of-sight between the aircraft and the ground control system can be increased by raising the elevation of the ground antenna. For this, retransmission equipment, satellite communications systems, as well as stationary data transmission systems, must be used. Also, to compensate the signal attenuation, measures such as increasing the transmitter output power and increasing the gain of antenna equipment can be taken [5].

4 Conclusion

Thus, the main purpose of this article was to analyse the hardware and software requirements for the possible use of UAV in oil spill identification tasks. As part of the work, the main stages of oil spill identification based on the use of UAV, and justified solutions for the use of special equipment to achieve more effective solutions to the problems of the oil and gas industry. In conclusion it should be noted that unmanned aerial vehicles provide a universal and effective solution to the oil and gas industry problems, in particular the problems of oil spill identification. Properly selected equipment and combinations of engineering make it possible to detect oil spills quickly and efficiently, reducing the economic losses of the enterprise and negative impact on the environment.

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