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Multimedia Support for Standardization of Oil Slick Shapes on the Sea Surface Based on Radar Satellite Data

Abstract

The work proposes an innovative approach to identification and quantitative assessment of oil slicks in the sea based on radar satellite data. Information multimedia support for standardization has been developed, based on the basic geometric shapes of oil slicks on the sea surface. In some cases, this approach allows for prompt assessment of the area of pollution. A diagram of the algorithm for animating an oil slick and a diagram of computer animation of the spread of an oil slick on the sea surface based on radar survey data have been developed. The advantages of monitoring using radar satellite data are shown. The main capabilities of the multimedia approach: presentation of information in new forms, presentation of information using a combination of multiple forms, a new level of interactive communication when modeling the problem under study. In general, this study has laid an important foundation for prompt and accurate identification and quantitative assessment of oil slicks in the sea.

Keywords: *multimedia, standardization, oil slick, radar data, modeling*

Introduction

Oil and gas exploration, oil production, improvement of transportation methods have not reduced the risks of negative impact on the environment (Kostianoy, 2016). The purpose of this work is to create multimedia material for standardization of basic forms of oil slicks on the sea surface based on radar satellite data (Lisickij, 2014; Sattarov, 2023, 483-488). Satellites equipped with radars are usually used to detect oil slicks on the sea surface. The resulting images of oil slicks are quite high-contrast. At the same time, optical satellite data carry important information about oil spills only in cloudless weather. Accelerated development of information technology contributed to the emergence of the concept of “multimedia”. This technology was aimed at using new forms of information in scientific research: animation, video, sound, etc. This contributed to an increase in the information content when modeling the problem under study.

Research

As is known, a standard is a normative and technical document establishing a set of norms, rules, requirements mandatory for implementation in certain areas of activity (GOST 1.06-68).

In this regard, the pollution standard is the maximum concentration of a substance that enters or is contained in the environment, permitted by regulatory documents. From the standpoint of ecology, an environmental standard is the degree of maximum permissible human intervention in ecosystems. It ensures the preservation of ecosystems of the desired structure and dynamic qualities (reliability and sustainability). An environmental global standard is the preservation of the biosphere and climate of the planet in a form that is suitable for normal human life.

As for the standardization of the environment (water, air, soil, etc.), it sets the limits within which changes in its natural properties are allowed. For example, to assess the state of the ecosystem of individual areas of the Caspian Sea, four gradations are adopted: stable, transitional, critical and catastrophic.

Based on the monitoring system materials, two concepts were considered that assess the quality of water and the ecological state of various water areas of the Caspian Sea. Global environmental problems are caused by human activity that is not consistent with the laws of nature. These problems include: climate change, reduction of the ozone layer, acid rain, reduction of biodiversity, depletion of natural resources.

The system of sources of environmental law includes the constitution, laws and by-laws. If the constitution forms the basis for legal regulation of environmental protection, then the most important source of environmental law is legislation. The formation of modern legislation on environmental protection is of priority importance. The most important legislation is on the protection of atmospheric air, water, soil. Thus, environmental monitoring is characterized as one of the measures of environmental protection, a function of public administration and a legal institution. Based on this, environmental monitoring is a system of long-term observations, assessment and forecast of the state of the natural environment and its changes.

Aerospace information is used in various industries and serves to solve practical problems, including:

- monitoring of oil pipelines;
- monitoring of oil pollution of the sea surface, etc (Zhantaev, 2019).

Aerospace monitoring of oil pollution of the sea surface is based on radar and optical satellite data. Optical satellite data of the observed region depends on weather conditions. At the same time, radar satellite data are all-weather. Thus, radar satellite information is most convenient for detecting oil spills and forecasting their spread.

Oil spills are classified both by shape (linear, curved, heterogeneous) and by size (less than 1 km, 1-5, 5-10, 10, more than 10 km). Oil pollution of the sea surface can occur as a result of accidents on drilling platforms, terminals, pipelines, tanker accidents, etc.

All-weather radar satellite data are the most convenient for detecting and forecasting the spread of oil spills. In order to promptly eliminate an oil spill, it is necessary to assess when and which areas of the sea surface will be subject to oil pollution. Visual observation data from the air (helicopters) and ships (ships), as well as satellite data, indicate the location of the spill at a certain point in time.

All methods of determining and tracking the trajectory of a slick have limitations. In this regard, preliminary graphical modeling of the dynamics of a slick on the sea surface is convenient. The movement of a slick is caused mainly by the combined effect of sea currents and wind (Lisitsky, 2016; Peterson, 2020).

Based on the above, a diagram of the algorithm for animating an oil slick has been developed and a diagram of computer animation of the spread of an oil slick on the sea surface based on radar data is given.

Figure 1 shows a schematic of the oil slick animation algorithm.

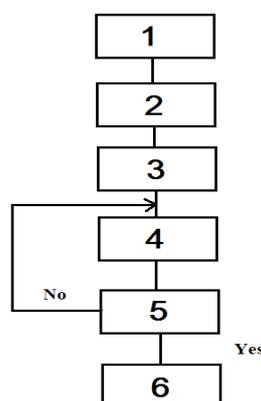


Figure 1. Scheme of oil slick animation algorithm

1– start; 2 – input of initial data; 3 – start of oil slick animation; 4 – increase in oil slick size, 5 – condition for achieving the specified slick size, 6 – end

Figure 2 – shows an animation diagram of oil slick spreading on the sea surface.

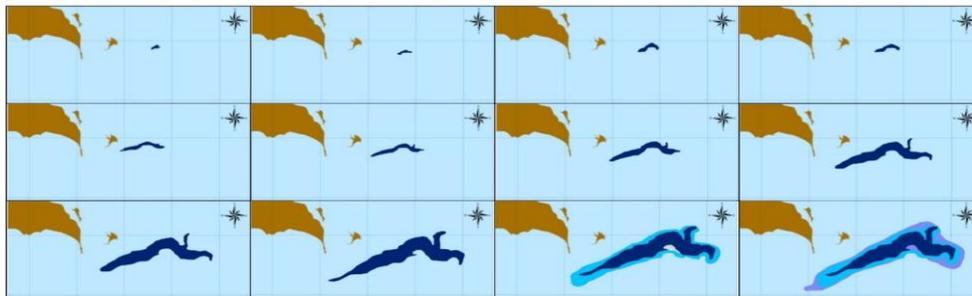


Figure 2. Animated diagram of the spread of an oil slick on the sea surface

During the evolution process, an oil slick undergoes a number of transformations. At the beginning, it has a complex shape, which is elongated in the direction of the wind. As noted in (Arkhipov, 2018), there are various approaches to modeling the spread of oil spills (in particular, models that lead to partial differential equations, models based on the wandering particle method). Such approaches allow for some additional features, the irregular shape of the spill, but they usually require large computational costs and are quite difficult to implement.

The accumulated experience in the process of computer animation of an oil slick has allowed us to develop the following approach.

In some cases, it is necessary to quickly calculate the area of the sea area polluted with oil.

In some cases, urgent calculation of the area of oil pollution at sea is required. We propose an approach for operational calculation of the area of oil pollution at sea based on remote sensing data. As you know, polygons (side length a) are as follows].

- triangular (number of sides 3);
- square (number of sides 4);
- pentagonal (number of sides 5);
- hexagonal (number of sides 6);
- octagonal (number of sides 8);
- decagonal (number of sides 10).

Triangular	$\frac{a^2}{4} \sqrt{3}$
Square	a^2
Pentagonal	$\frac{a^2}{4} \sqrt{25 + 10\sqrt{5}}$
Hexagonal	$\frac{3}{2} a^2 \sqrt{3}$
Octagonal	$2a^2(1 + \sqrt{2})$
Decagonal	$\frac{5}{2} a^2 \sqrt{5 + 2\sqrt{5}}$

According to the series of variables a = 10 - 100, the corresponding areas for a number of polygons were calculated (Sattarov, 2024). The above contributes to the intensification of computer graphics modeling in the assessment of the area of sea surface pollution. Below are fragments of the calculation of the areas of polygons using the corresponding formulas (Biao Zhang, 2011; Li, D, 2023).

Triangular	
a1 = 10	Σ1 = 43.3
a2 = 20	Σ2 = 173.20
a10 = 100	Σ10 = 4330

	Square	
a1 = 10		$\Sigma 1 = 100$
a5 = 50		$\Sigma 5 = 2500$
a9 = 90		$\Sigma 9 = 8100$
	Pentagonal	
a2 = 10		$\Sigma 1 = 684,025$
a3 = 30		$\Sigma 3 = 6156,225$
	Hexagonal	
a1 = 10		$\Sigma 1 = 259,8$
a4 = 40		$\Sigma 4 = 4156,8$
	Octagonal	
a2=10		$\Sigma 1 = 482,84$
a6=60		$\Sigma 6 = 17382,24$
a9=90		$\Sigma 9 = 39110,04$
	Decagonal	
a1 = 10		$\Sigma 1 = 1677,075$
a10 = 100		$\Sigma 10 = 167707,5$

Figure 3 shows several regular polygon shapes.

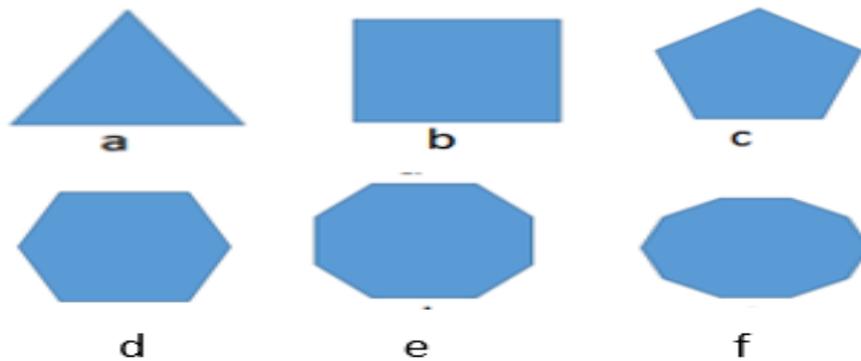


Figure 3. Several regular polygonal shapes

a - triangular, b - square, c - pentagonal, d - hexagonal, e - octagonal, f – decagonal

Further development of this method is the collection, careful selection of informative characteristics of the problem area based on IF – THEN heuristics. The above will provide intellectual support in solving the problem based on cognitive and expert systems technologies (Stuart, 2020; Sattarov, 2024).

Conclusion

1. It is known that the total area of the surface that borders the oil slick (rectangle) is calculated by multiplying the length by the width.
2. The proposed method allows one to determine the area of the polygon by the known length of its edge.
3. The shape of the newly formed slick (from several hours to several days) depends mainly on the wind.
4. The noted geometric images can serve as material for standardizing the basic shapes of oil slicks at sea.
5. Further development of the proposed method will be intellectual support based on cognitive and expert systems technologies.

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