OIL SPILL DETECTION IN SAR IMAGES USING TEXTURE ENTROPY ALGORITHM AND MAHALANOBIS CLASSIFIER

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Abstract:

Oil spill has become critical in some countries, especially for countries that have seas or oceans. The situation has caused damage to the environment and polluted the water. To reduce environment damage and protect life in water, plants and soil near to disaster area .Study and analysis should be carried out .The causes and factors that lead to the disaster of oil spill should be studied or investigated. To analyze the problem of oil spill we consider 2 algorithms. These methods help in the analysis and identification of oil spill in SAR images.

Since the 1980s, satellite-borne synthetic aperture radar (SAR) has been investigated for early warning and monitoring of marine oil spills to permit effective satellite surveillance in the marine environment. Synthetic Aperture Radar (SAR) imaging system is used to monitor the marine system. Oil spill pollution plays a significant role in damaging marine ecosystem. One main advantages of SAR is that it can generate imagery under all weather conditions. Automated detection of oil spills from satellite SAR intensity imagery consists of three steps: Detection of dark spots , Extraction of features from the detected dark spots and classification of the dark spots into oil spills and look-alikes.

Texture Entropy Algorithm is a method based on the utilization of texture algorithms for the discrimination of oil spill areas from the surrounding features, e.g. sea surface and look-alikes.

Mahalanobis Classifier method first estimates covariance matrix and then Mahalanobis Distance is calculated for identification of oil spill or lookalike.

Keywords*:* Texture Entropy Algorithm, Mahalanobis Classifier, SAR (Synthetic Aperture Radar).

1. Introduction

An oil spill is the release of a liquid petroleum hydrocarbon into the environment, especially marine areas, due to human activity, and is a form of pollution. The term is usually applied to marine oil spills, where oil is released into the ocean or coastal waters, but spills may also occur on land. Oil spills may be due to releases of crude oil from tankers, offshore platforms, drilling rigs and wells, as well as spills of refined petroleum products (such as gasoline, diesel) and their by-products, heavier fuels used by large ships such as bunker fuel, or the spill of any oily refuse or waste oil. Oil penetrates into the structure of the plumage of birds and the fur of mammals, reducing its insulating ability, and making them more vulnerable to temperature fluctuations and much less buoyant in the water. Animals that rely on scent to find their babies or mothers fade away due to the strong scent of the oil. This causes a baby to be rejected and abandoned, leaving the babies to starve and eventually die. Oil can impair a bird's ability to fly, preventing it from foraging or escaping from predators. Various sensors can be utilized to perform the task, including the ultraviolet sensors, visible sensors, infrared sensors, and microwave sensors. During the past two decades, much attention has been given to the utilization of SAR (Synthetic Aperture Radar). SAR is an active microwave imaging system that transmits short directional electromagnetic (EM) wave pulses and then operates as a sensitive receiver to record the backscatter signals to form a two-dimensional (2-D) image. SAR is an appropriate tool for oil spill monitoring. Usually 3 basic steps are followed by every algorithm to identify oil spill or lookalike: Detection of dark spots, feature extraction and classification.

2. Related Work

Detection of Oil Spill in SAR images is important to maintain balance in the eco system and save marine life.SAR sensors a the most efficient sensors for detection of oil spill most of the algorithms use SAR sensors for better performance [6]. Many algorithms have been proposed for oil spill detection; here I will be presenting a detailed comparison of texture entropy algorithm and Mahalanobis Classifier.

[3] Initial texture algorithms use co-occurrence matrix for finding various features like range, variance, standard deviation, entropy etc. However, computing the texture features from a co occurrence matrix may become critical due to the multiplicative noise impacts. [4] Using entropy algorithm would solve the problem of multiplicative noise.

[5] Mahalanobis classifier is based on a correlation between variables by which different patterns can be identified and analyzed. It is a useful way of determining similarity of an unknown sample set to a known one.

2.1. *Texture Entropy Algorithm [3]*

Texture is one of the important characteristics used in identifying objects or region of interest in an SAR images. The discrimination of oil spills from look-alikes is usually carried out with the use of classification procedure based on different characteristics observed from both oil spills and look-alikes. Such characteristics include geometry, physical characteristics of image intensity, texture and other contextual information describing the slick in relation. This work presents a method based on the utilization of texture algorithms for the discrimination of oil spill areas from the surrounding features**,** e.g. sea surface and look-alikes, using SAR data. Texture entropy algorithm is used for oil spill detection from SAR data. They found that the oil spill pixels are smoother than the surrounding environment. In fact, texture entropy algorithm has removed the speckle from oil spill pixels in SAR data. This work has hypothesized that the dark spot areas (oil slick or look-alike pixels) and its surrounding backscattered environmental signals in the SAR data can be modeled as texture. In this context, co-occurrence texture algorithm entropy can be used as a semi automatic tool to discriminate between oil spills, lookalikes and surrounding sea surface waters to its surroundings.

2.1.1. *Algorithm [4]*

STEP1: SAR data of image is to be taken as input

STEP2: Backscatter estimation and Incidence angle is to be found out . Usually d=1 and Θ =0 degree are to be chosen for better results. Distance d is usually taken as 1 while Θ can have various as 0, 45, 90,135.

STEP 3:

Entropy is to be calculated as given in equation (1):

$$Ent = \sum \sum p_{ij} \quad \log p_{ij} \tag{1}$$

STEP 4: Adaptive thresholding method to be used for segmentation of dark spot

STEP 5: Once dark spot is detected. Co-occurrence is applied to categorize the image to “oil slick” and water.

Mathematically, a co-occurrence matrix C is defined over an $n \times m$ image I, parameterized by an offset (Δx,Δy) as given in equation (2) :

$$C_{\Delta x,\Delta y(i,j)} = \sum_{p=1}^{n}\sum_{q=1}^{m}\begin{cases}1, & \text{if } I(p,q)=i \text{ and } I(p+\Delta x, q+\Delta y)=j \\ 0, & \text{otherwise}\end{cases} \tag{2}$$

Various features can be calculated co-occurrence matrix which will further help in detection of oil spill and look alike

In this study, the window size is 7 × 7 pixels is used. The window size of 7 × 7 gives more details on an image. Window size is used for producing the co-occurrence matrix for each input pixel.

2.1.2 *The Texture Entropy Algorithm Analysis*

Advantages:

- Pre-processing on the SAR data is done in order to remove the speckle noise.
- It uses adaptive thresholding which increases the overall efficiency.
- Small number of parameters and gives clear cut boundaries for dark spot detection.

Disadvantages:

- Sometimes the approach might become complex and less flexible because of the co occurrence matrix.

2.2. *Mahalanobis Classifier [5]*

Mahalanobis is the second classification algorithm for detection and classification of oil spill in SAR images. Mahalanobis classifier is named after the founder P. C. Mahalanobis. This algorithm is based on a correlation between variables by which different patterns can be identified and analyzed. It gauges similarity of an unknown sample set to a known one. It differs from Euclidean distance in that it takes into account the correlations of the data set and is scale-invariant. Mahalanobis distances provide a powerful method of measuring how similar some set of conditions is to an ideal set of conditions, and can be very useful for identifying which dark spot in a SAR image is oil spill or lookalike. Mahalanobis distances are based on both the mean and variance of the predictor variables, plus the covariance matrix of all the variables, and therefore take advantage of the covariance among variables. The region of constant Mahalanobis distance around the mean forms an ellipse in 2D space (i.e. when only 2 variables are measured), or an ellipsoid or hyperellipsoid when more variables are used. Mahalanobis distance vector is given by equation (3):

$$D_{M_{(v)}} = \sqrt{(v-\mu)^T S^{-1}(v-\mu)} \quad (3)$$

where $v=(v_1,v_2,v_3.........v_n)^t$ from group of variables with mean $\mu=(\mu_1, \mu_2, \mu_3........ \mu_n)^t$ and S is co-variance matrix.

Example of Mahalanobis distances are calculated for single value:

$D^2 = (v-\mu)^T S^{-1}(v-\mu)$
Where:
D^2 = Mahalanobis distance
v = Vector of data
μ = Mean values
S^{-1} = Inverse of Co variance
T= Indicates transpose

Variance/Covariance Matrix		
	X	Y
X	6291.55737	3754.32851
Y	3754.32851	6280.77066

Mean μ = 500; X= 410; Y= 400

$$(v-\mu) = \begin{bmatrix} 410-500 \\ 400-500 \end{bmatrix} = \begin{bmatrix} -90 \\ -100 \end{bmatrix}$$

$$S^{-1} = \begin{bmatrix} 6291.55737 & 3754.32851 \\ 3754.32851 & 6280.77066 \end{bmatrix}^{-1} = \begin{bmatrix} 0.00025 & -0.00015 \\ -0.00015 & 0.00025 \end{bmatrix}$$

$$D^2 = (-90\ -100) * \begin{bmatrix} 0.00025 & -0.00015 \\ -0.00015 & 0.00025 \end{bmatrix} * \begin{bmatrix} -90 \\ -100 \end{bmatrix}$$

= 1.825

2.2.1 The Mahalanobis Classifier Analysis

Advantages:

- Mahalanobis space can constructed for any number of variables.
- Mahalanobis distance can be obtained without assumption of distribution of variables.
- Mahalanobis distance takes into consideration the correlations between the variables.

Disadvantages:
- Does not do any pre processing on the SAR data so efficiency gets affected by speckle noise.
- Being data-driven technique, it requires data for normal and abnormal scenarios.
- Offline analysis technique.

3. Result

This section compares the experimental performance of Texture Entropy Algorithm and Mahalanobis Classifier. Various parameters were considered to form comparison between the 2 methods as stated in Table 1:

Table: 1 Comparison table for Texture Entropy and Mahalanobis Classifier.

Algorithm	**Texture Entropy Algorithm**	**Mahalanobis Classification**
Images and/or resolution	SAR images	SAR images
Dark formation detection method	Adaptive Thresholding	Simple Thresholding
Preprocessing	a) Incidence Angle b) Backscatter Estimation	No Pre-processing done
Error standard deviation	0.2 approx	0.3 approx
Accuracy	94% approx	89% approx
Efficiency	High as compared to Mahalanobis classifier	Low

4. Conclusion

In this paper, comparative algorithms for oil spill detection from different SAR data to discriminate between oil spill and look alike are analyzed. Two algorithms are involved: Texture Entropy Algorithm and Mahalanobis Classifier. The study shows that Texture Entropy Algorithm is more efficient as compared to Mahalanobis because it uses adaptive thresholding for detection of dark spot while Mahalanobis classifier uses simple thresholding. Texture Entropy Algorithm performs pre-processing on the SAR data for reduction of speckle noise. Error standard deviation for Texture Entropy is 0.2(approx) which is less as compared to Mahalanobis classifier.

5. References

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