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SATELLITE BASED OIL SPILL MONITORING AND DETECTION IN OCEANIC WORLD USING ADAPTIVE THRESHOLD TECHNIQUES

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ABSTRACT

In this paper an adaptive threshold Techniques has been used which aimed to solve problem of oil spills in oceanic world. As we know oil spill is the biggest issue faced by marine species to overcome this problem an adaptive threshold method is applied for automatic monitoring and detection of oil spills in the ocean. This research is implemented using SAR RADARSAT-2 Narrow single beam data acquired in the Gulf of Mexico SAR image. The study demonstrates occurrence of oil spill in the ocean using image data obtained from the different satellite and detection of dark patches and bands in the images with low time complexity. In conclusion, adaptive threshold can be used as a tool for automatic detection of oil spill as well as SAR satellite image serves as an excellent sensor for oil spill detection and surveying.

Keyword: adaptive threshold, radar, oil spill, dark spot, band, sensor.

1. INTRODUCTION

Large spills of oil such as petroleum, crude etc. products in the marine world may have strongly environmental impacts. For oil spills monitoring remote sensing plays an important role. Media and public plays an intense role in restricting illegal spills by finding locations and the extent of oil spills in marine environment through continuous monitoring Open Ocean on a 24-hour basis with knowledge of slick locations. Integrated marine and coastal management is a frame work which includes comprehensive planning, assessment, setting of objective and management of coastal and marine resources, it is an evolutionary process for implementing and developing a continuous management capability that can response based on condition. Most common oil spill mapping and surveillance are carried out with simple video photography also. Oil spill tracking and monitoring are still done today through aircraft process. Today in international and nation sea body oil spill can be monitored using radar sensors which are now increasingly common techniques. Satellite is adapted to track discharge of oil and to monitor oil spill since they took regularly day to day images of the sea surface. Several measurements have been adapted such as infrared, optical, radars with different ranges and frequencies. As we know Synthetic Aperture Radar (SAR) images can produce image with high polarization band. So Synthetic Aperture Radar (SAR) images seem to be most useful instruments for detection of slick. Slicks damp highly short waves which measured by Synthetic Aperture Radar and dark patch on the Synthetic Aperture Radar image represent oil spills. The condition related to Synthetic Aperture Radar (SAR) measurements are as following: (1) speed of the wind in between 2-3 to 10-14 m/s. (2) to distinguish oil spill from other phenomena such as look-alikes, wind shadow, sea roughness, heavy rain, grease ice and upwelling zones.

Figure-1. Oil spill impact and problem faced by marine animals in Gulf of Mexico image.

2. LITERATURE REVIEW

In [1], Iphigenia Keramitsoglous, Chris T. Kiranoudisb proposed Automatic identification of oil spill on satellite image in February 2005 in this approach they proposed artificial intelligence fuzzy logic technique to assigns probability of dark image of oil spill. In [2], H. Harahsheh, S. Essa, M. Shiobarac, T. Nishidaid, T. Onumad proposed operational satellite monitoring and detection for oil spill in offshore of united ARAB emirates in March 2007 they proposed Multi-Temporal Image analysis technique frequency occurrences of oil spill in Arabian and Oman gulf. In [3] Mark Reed & Istein Johansen proposed oil spill modeling towards the close of the 20th century state of art in 2000 in this approach numerical model used for describing prediction process rate in oil spill modeling. In [4], N. Nouri, A. Ghorbanali & A. Alesheikh introduced remote sensing change detection in coast line in 2007 December, they define a combination of band ratio and histogram to produces variation in coastline with ground truth observation of image. In [5], 2014 Maged Marghany introduced an evolutionary in multi objective oil spill detection using COSMO Sky Med satellite image for optimal solution to represent oil silk pattern with 96%, 3% and 1% of oil slick, roughness of sea and look alike features. In [6], 2015, Maged Marghany, proposed Genetic Algorithm using SAR Radarset-2, to detect footprint of oil slick. In [7], 2016, Maged Marghany, introduce receiver- operating characteristic (ROC) curve to represent footprints of slick. In [8], 2008, Yang Gao, Maya Nand Jha & Jason Levy, classified sensors characteristic. To detect oil spills Scanning Laser Environmental Airborne Fluoro sensor used. In [9], 2010, Bioucas Dias and Sonia Pelizzari proposed Bayesian Segmentation to find density of backscattered of an image. In [10], 2005, Gianmarco Radice and Matteo Ceriotti suggested to define backscatter of oil spill. In [11], 2008, D. Argialas and K.Karantzalos proposed level set segmentation to detect oil spill using satellite images. In [12], 2004, Anne H.S. Solberh & Camilla Brekke, , September 2004,find out difference between the oil slick based pattern and look alike.

Table-1. Some of the remote sensing satellite

Satellite	Launch date	Owner/Operator	Band
ERS-1	1991(END 2000)	European Space Agency	C
ERS-2	1995	European Space Agency	C
RADARSAT-1	1995	Canadian Space Agency	C
RADARSAT-2	2007	Canadian Space Agency	C
ENVISAT(ASAR)	2002	European Space Agency	C
ALOS(PALSAR)	2006(end 2011)	Japan Aerospace Exploration Agency	L

3. METHODOLOGY

For oil spill identification it consists of following steps. Preprocessing, mask operation, adaptive thresholding, clustering and dark patches and feature extraction.

3.1 Preprocessing

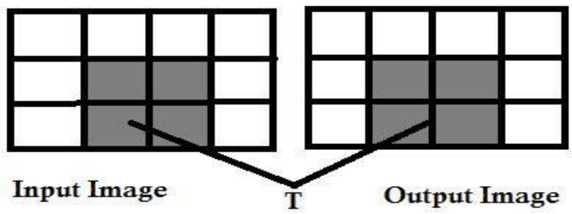
In Preprocessing, original Synthetic aperture radar data is converted into geographical projection and common format. It improve image based on requirement. Let consider element g (m, n) for projection.

3.2 Mask operation

Masking is the second step, it mask all small islets, innermost water area, land area where wind dampening shadows always appear which helps for easily detection of dark patches and bands in SAR data. Here each pixel modified according to small neighborhood pixel. Each pixel modified based on equation that is not dependent on other neighborhood value of pixel and mapping from one pixel to new pixel take place.
Equation represented as:

$$g(m, n) = T[f(m, n)]$$

Where, T is one to one mapping between input g (m, n) and output f (m, n) images.



A pixel at g (m, n) coordinate has four horizontal and vertical neighbors which is represented by-
g(m,n) = (m+1,n),(m-1,n),(m,n+1),(m,n-1)

	(m,n-1)	
(m-1,n)	g(m,n)	(m+1,n)
	(m,n+1)	

3.3 Adaptive thresholding

Adaptive Thresholding is the third step, in this algorithm Adaptation is important due to radar contrast between dark spot, surrounding weather and wind speed condition which can change during investigation. As we know threshold level depends in incidence angle even in constant conditions in weather within the synthetic aperture radar image. After initial thresholding according to predetermined rules the threshold value must be change. Adaptive thresholding have pixel with similar intensities that produce segments, which help to produce boundaries in images. They produce large number of gray level values

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with local and global information of image. Threshold value ɵ is selected

$$f(m,n) = 1\ if\ f(m,n) \geq ɵ\ else\ 0$$

A threshold T(x, y) is calculated based on statistics such as range, boundaries and variance. Here, the intensity of pixel value is stored in array. Threshold is calculated using mean and variance, so pixel set to '0 and 1'. Pixel is divided in two classes, with gray levels.

P_1 with gray level [1,…t]
P_2 with gray level [t+1,…l]
P_1: $[m_1/n_1(t)\ldots\ldots m_t/n_1(t)]$ and
P_2: $[m_{t+1}/n_2(t)\ldots\ldots m_l/n_2(t)]$
$N_1(t) = \sum_{i=1}^{t} m_i$ and
$N_2(t) = \sum_{t=t+1}^{l} m_i$
For mean of two classes denotes as
$\mu_1 = \sum_{i=1} im_i/n_1(t)$ and
$\mu_2 = \sum_{i=t+1}^{l} im_i/n_2(t)$
Now, define class variance of the threshold image
$\sigma^2{}_P = n_1(\mu_1-\mu_2)^2 + n_2(\mu_1-\mu_2)^2$

3.4 Clustering

Clustering is the fourth step, it check the border between surrounding sea and dark spot. In clustering steps each spot is clustered into two. If they apart and darkest cluster is large as compared to brightest, then darkest cluster will used as spot otherwise original will be used as spot. Here it increases the probability of dark features with increase in radar contrast between surrounding water and spills, which represent as a function of environmental conditions, spill parameter and weather conditions. Let consider K as initial clusters so K = $m_1(1), m_2(1), m_3(1)\ldots\ldots m_k$.

$x € C_j(K)$ $if[x-m_j(k)] < [x-m_i(k)]$, For $i = 1,2,3\ldots K$, $i \neq j$, where $C_j(k)$ denotes sample set with cluster $m_j(k)$

$P_j(k+1) = 1/Nj \sum_{x€Cj} x$, j=1,2,3…..k

3.5 Feature extraction

It extract the features of oil from look-alikes is computed from each area to detect dark spot and bands with a low time complexity. It depends upon set of features selection such as: area of slick, it represent object which is based on pixel values, slick smoothness, define intensity of region which is denoted by 'R'. Slick smoothness (R) = $1-1/(1-\sigma^2)$, standard deviation used to represent contrast average, mean value used for intensity, uniformity or energy function used to measure gray level maximization in image, entropy (e), it define randomness for image, equation given as $\sum_{i=0}^{l-1} p\ (m_i) \log_2 p(m_i)$.

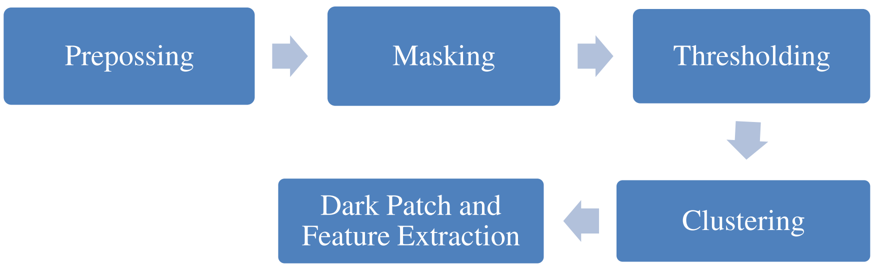

Figure-1. It represents oil spill identification based on adaptive thresholding.

4. RESULTS AND DISCUSSIONS

The adaptive threshold technique was examined on three SAR image to identify dark patches and bands. Synthetic aperture radar image confirmed dark patches and bands of oil spills about 70km away from Louisiana in Gulf of Mexico coast. Radar image acquired during and after oil spill incident, which was happened on 27 April 2010. In which crude oil spread across 19,112 square miles in 49,500 km^2 in Gulf of Mexico. In these paper first two images taken from Gulf of Mexico. Oil spill has darkest colour than the surrounding water and boats. The first SAR image was taken on 27 April 2010 with resolution 79.9-37.7x60 incidence angle of 20-46 with HH polarization. Second image taken on 1st May 2010, Gulf of Mexico with resolution of 79.9-37.7x60, incidence angle of 25 ° -46 ° with HH polarization, which show four days interval of period. Figure-3, represent back scatter intensity with oil spills. It was damped -30 decibel to -25 decibel which decrease in time as oil spill slowly increased. The footprint of ship backscatter in constant it maximized by -5 decibel in 7 meters. The SAR mode provide HH polarization with single pass based on satellite with spacing of pixel 25x25 nominal pixel spacing (m). It provides coverage range of 32° - 48° with shallow incident angle. For oil spill identification shallow incidence angle and C band found suitable for research work. Based on large incidence angle and HH polarization water roughness created by wind seems to be reduced. For oil spill identification SAR width increase up to 300km, this shows great achievement for ocean oil monitoring and

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detection. SAR provides extreme level of flexibility compare with other sensors.

In Figure-4, it indicates oil spills with positive dark patches and surrounding area with negative patches according to image. Here each pixel is compared with other pixels, which determine whether it is negative or positive region. In many case gray level is not constant in background and the contrast of object also varies in image. In such case adaptive thresholding is good and convenient because gray level slowly varying according to image position so it make easy to monitored and detect oil spills even in bad weather condition. Based on negative value it shows features of look-alike such as sea roughness, ships, wind shadows. In such situation, the value which is below threshold level and less than zero must be diminished. In this adaptive thresholding algorithm output indicates black colour with oil spills and white colour with surrounding features. Based on this algorithm oil patches and bands are correctly identified.

Table-4 defines the significant difference for oil spill performance matrix with statistics value, critical value, standard error and time per seconds. In this table the statistics value 0.80 is smaller than the critical value 1.21 with standard error 0.12 in 65 seconds which show detection of oil spill from surrounding water features is more accurate and excellent classifier of oil slick region in the image with low time complexity. This proves that adaptive thresholding can be used as a tool for automatic detection of oil spill and SAR satellite image serves as an excellent sensor for oil spill detection and surveying. This proves adaptive threshold is powerful techniques which produce oil spill patches and band on global scale.

Table-2. Synthetic aperture radar characteristics.

S. No.	**Beam mode**	**Place**	**Date**	**Nominal pixel spacing** (m)	**Resolution** (m)	**Incident angle** (Degree)	**Polarization**
1	ENVISAT ASAR	Gulf of Mexico	27 April 2010	25 x 25	79.9-37.7 x 60	20-46	HH
2	ENVISAT ASAR	Gulf of Mexico	1st May 2010	25 x 25	79.9-37.7 x 60	25-46	HH

Figure-2. Gulf of Mexico oil spill satellite image ENVISAT ASAR, dated 26 April 2010.

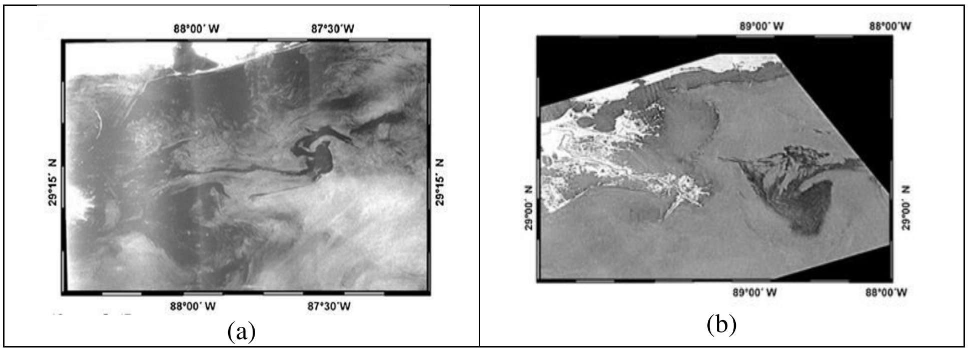

Figure-3(a). Gulf of Mexico oil spill satellite image ENVISAT ASAR, dated 27 April 2010.

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(b) Gulf of Mexico oil spill satellite image ENVISAT ASAR, dated 1st May 2010.

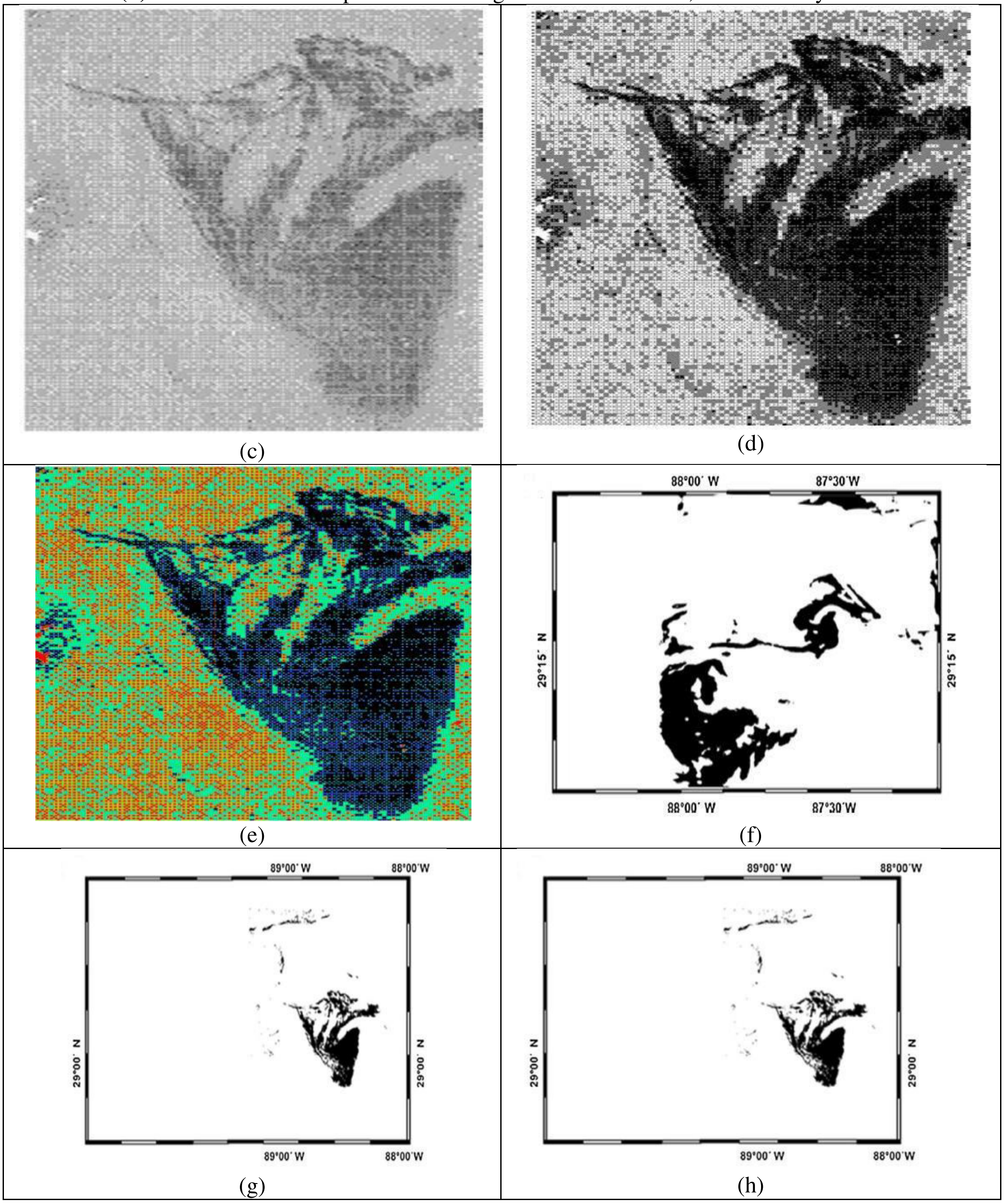

Figure-4. Results of Adaptive thresholding for detection of dark spot patches and band in the images with low time complexity, (c) pre-processing, (d) masking, (e) Thresholding, (f) clustering, (g) Dark Patch and Feature Extraction, (h) Final detection of oil using Synthetic aperture radar image.

Table-3. Significant differences for oil spill performance matrix.

S. No.	**Data**	**Statistics value**	**Critical value**	**Standard error**	**Time** (Sec)
1	ENVISAT ASAR	0.80	1.21	0.12	65
2	ENVISAT ASAR	0.87	1.22	0.13	70

5. CONCLUSIONS

An adaptive threshold Technique is used which aimed to solve problem of oil spills in oceanic world. As we know oil spill is the biggest issue faced by marine species to overcome this problem an adaptive threshold method is applied for automatic monitoring and detection of oil spills in the ocean. This research is implemented using SAR RADARSAT-2 Narrow single beam data acquired in the Gulf of Mexico SAR image. The study demonstrates occurrence of oil spill in the ocean using image data obtained from the different satellite and detection of dark patches and bands in the images with low time complexity. In conclusion, adaptive threshold can be used as a tool for automatic detection of oil spill as well as SAR satellite image serves as an excellent sensor for oil spill detection and surveying.

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