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COMPARISON TECHNIQUE IN OIL SPILL ANALYZING USING REMOTE SENSING

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Abstract- *Oil tanker collided in Gulf of Mexico on 27 April 2010 and spilled 3000 tons of oils in sea. The objective of doing this research work is to develop an oil spill detection techniques using Advance synthetic aperture radar images. Here three images were taken to observe the differences, patches, area and pattern of oil spills in Gulf of Mexico region. This research compares algorithms and find out which suited best for detection and monitoring of oil spills in ocean. After comparing algorithms, Expectation maximization is best suited for oil spill detection with less time consuming and ASAR play good sensors for research and development.*

Keywords: *Oil spill, pattern, tracking, Expectation maximization Techniques.*

I. INTRODUCTION

Oil spill is one of the most important problem occurs in the world which become one of the biggest issue in marine life. So regular monitoring is important, which helps to solve problems based on oil spill. Extraction of oil from ocean is a fundamental work done for agencies to regular monitoring the sea. In this scenario satellite image play an important role for data acquisition. In ever year oil spill accident take place in history it was on the Gulf of Mexico in Deepwater Horizon on April, 20, 2010, with explosion in July 15, 2010. It effected on wildlife habitats and maritime spices. To overcome this problem radar image was used for regular monitoring which improves over all oil spill problems by various approaches. To survey oil spill SAR image provide various advantage for detection and tracking of oil spills. Several satellite SAR sensors are involved in the oil spill detection and survey. These data are from ERS-1/2, (Brekke and Solberg 2005) ENVISAT (Marghany 2013), ALOS, (Zhang et al. 2011, 2012), RADARSAT-1/2, (Zhang et al. 2012) and TerraSAR-X (Velotto et al. 2011) which have been globally used to identify and monitor the oil-spill. Recently, the multi polarimetric SAR high-resolution data have become a vital research area for oil spill detection (Skrunes et al. 2012; Shirvany et al. 2012). Oil spill detection and monitoring using SAR technology, data are scarce job, because of barely discrimination between oil spill and other features of look-alike ,shadows, wind speed that appear patches in SAR data as Dark patches (Topouzelis 2008). The problems faced in oil spill automatic using SAR data, is achievements in past decades. Simultaneously, Frate et al. (2000) proposed semi-automatic oil spill detection by using neural network, in which a vector defining features of an oil-spill is used. Topouzelis et al. (2007, 2009) and Marghany, Hashim (2011) confirmed that neural network technique could give precise difference among look-alike and oil- spill in SAR data. Topouzelis et al. (2007) has used neural networks in finding both oil-spill and dark patches detection. Experimental results shows, 89 % accuracy and 94 % dark patches segmentation but certain disadvantages like they cannot efficiently detect small and fresh spills. Skrunes et al. (2012), reports that there are several disadvantages associated with SAR sensors based oil spill detection. So they suggested using multi-polarization acquisition data, such as Terra SAR-X satellites and RADARSAT-2.

II. DATA ACQUIRED

In this study, RADARSAT-2 SAR data acquired by RADARSAT-2 operating with Scan SAR Narrow single mode beam on 27th April, 2010; 1st May 2010; and 3rdMay, 2010 are investigated for detection of oil spill in the Gulf of Mexico. The satellite armed with Synthetic Aperture Radar (SAR) with multiple modes of polarization, which includes fully polar metric mode of operation in which HH, VV and VH polarized data's were acquired (Maurizio et al. 2012). It has got highest resolution of 1 m in Spotlight beam mode (Ultra Fine mode of 3 m) with 100 m of positional accuracy. In the Scan SAR Wide Beam mode (WBM), the SAR has nominal width of 500 km and 100 m imaging resolution. The ground data obtained are based on study of Garcia-Pineda et al. (2013) where majority of oil types are emulsion and silver sheen.

Sl. No	Beam mode	Place	Date	Nominal pixel spacing(m)	Resolution (m)	Incident angle	Polarization
1.	ENVISAT ASAR	Gulf Of Mexico	27 April 2010	25 x 25	79.9-37.7 x 60	20-55	HH
2.	ENVISAT ASAR	Gulf Of Mexico	1 May 2010	25 x 25	79.9-37.7 x 60	20-46	HH
3.	ENVISAT ASAR	Gulf Of Mexico	3 May 2010	25 x 25	79.9-37.7 x 60	25-50	HH

Table1. ENVISAT ASAR IMAGE

Figure1. Input images

III. MATERIAL AND METHODOLOGY

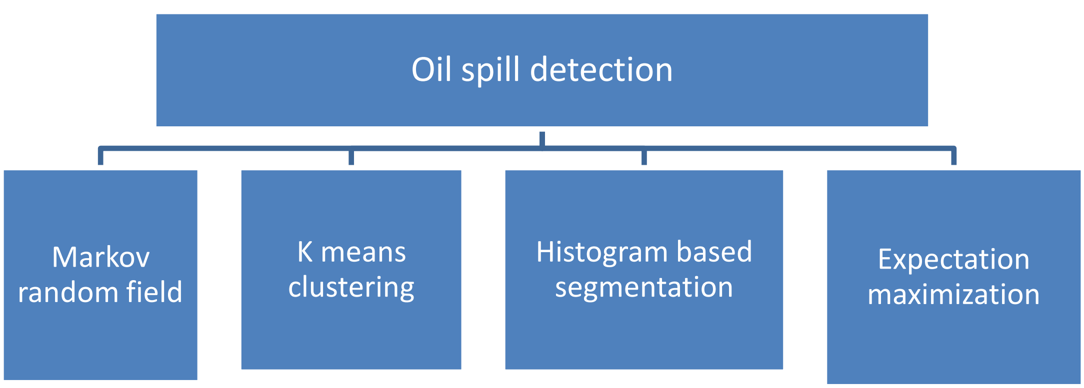


Figure2. Methodology

1. Markov random field

Markov random field technique provides mutual influences in given data, which helps to provide more clear detection on oil spills in images with objective function modification. With the help of modification process it helps in reducing speckle noise effect in radar images. It works together with membership function using neighborhood pixels. Steps are as follows- (1) initially two satellite image has to be taken, consider as $P_1 = \{P_1(I,h), 1 \leq I \leq M, 1 \leq h \leq N\}$ and $\{P_2(I,h), 1 \leq I \leq M, 1 \leq h \leq N\}$, where M x N. (2) in second step generate logarithmic and mean operator to cover over all area taken for monitoring it is denoted with $l = \frac{k_1}{f_1}$, $mean = 1 - \min(\frac{k_1}{f_1}, \frac{k_2}{f_2})$, Where as, , f_1 & f_2, k_1 & k_2 are logarithmic and mean values. Here Mean produces difference images using information of pixels. Log value used to find out intensity for images and it covers larger area. Let us considered iteration x =1 with standard deviation σ_r^1 *and* mean μ_r^1 values. Now find out energy function E_{pq}^x with iteration 'x'. Now apply Gibbs expression, to find out prior probability (π_{pq}^c)

$$\pi_{pq}^c = \frac{\exp(-\mathrm{E}_{\mathrm{pq}}^{\mathrm{x}})}{\exp(-\mathrm{E}_{\mathrm{pq}}^{\mathrm{x}}) + \exp(-\mathrm{E}_{\mathrm{pq}}^{\mathrm{x}})}$$

Now (p_r^c) determine conditional probability then generate the distance matrix (d_{pq}^c) for the given input image.

$$p_r^c\left(\frac{y_j}{\mu_r^c, \sigma_r^c}\right) = \frac{1}{\sigma_r^c\sqrt{2\pi}} exp\left[-\frac{y_{j} - {\pi_r^c}^2}{2(\sigma_r^c)^2}\right]$$

$$d_{pq}^c = -1n\left[p_r^c\left(\frac{y_j}{\mu_r^c, \sigma_r^c}\right)\right]$$

Now compute objective function- $d_{pq}^c = -1n\left[p_r^c\left(\frac{y_j}{\mu_r^c, \sigma_r^c}\right)\right]$,

$$\left|J_{pq}^c - J_{pq}^{c-1}\right| \leq \delta$$

Now determine Membership matrix $\{\mu_{pq}^{c+1}\}$

$$\mu_{pq}^{c+1} = \frac{\pi_{pq}^c \exp(-d_{pq}^c)}{\pi_{pq}^c \exp(-d_{pq}^c) + \pi_{pq}^c \exp(-d_{pq}^c)}$$

Update deviation and mean values σ_r^{c+1} and μ_r^{c+1}respectively, *c*=*c*+1

$$\mu_r^{c+1} = \frac{\sum_x(\mu_{pq}^c\, y_j)}{\sum_x(\mu_{pq}^c)}$$

$$\sigma_r^{c+1} = \sqrt{\frac{\sum_x[u_{pq}^c\ (y_j - \mu_r^{c+1})^2]}{\sum_x(u_{pq}^c)}}$$

2. K-mean clustering

K mean clustering is a vector quantization method used for oil spill detection. Here each element is partition into k clusters which belongs to nearest mean, act as prototypes for the cluster. It works on dividing data cell into voronoi cells. K mean cluster determine comparable spatial extent clusters. It classifies data which is new into existing clusters which called as centroid nearest classifier.

Let as consider set observations $(a_1, a_2, a_3, \ldots\ldots a_n)$ with D real vector dimensional. Here 'c' means clustering partition number of observation into c $\leq n$ sets which is denoted as S = $\{set_1, set_2, set_3 \ldots. set_k\}$, it will minimize sum of squares with cluster.

$\arg_S minimum \sum_{set=1}^{c} \sum_{a \in set_i} ||a - \mu_p||^2 = arg_{set}\, minimum \sum_{p=1}^{c} |set_p| vars_p$, μ_i is points mean of set_p which is similar to squared pairwise deviations in same cluster.

arg_{set} min$imum$ $\sum_{p=1}^{c} \frac{1}{2|set_p|} \sum_{a,y \in set_p} ||x - y||^2$

similar features can be deleted by using formula $\sum_{a \in set_i} ||a - \mu_p\Big|\Big|^2 = \sum_{a \neq y \in set_p} (a - \mu_p\Big)(\mu_p - y)$, which shows number of total variance is constant between points in cluster.

Let as consider k mean initial set $n_1^{(1)}, \ldots \ldots \ldots n_k^{(1)}$, with assign observation in cluster, where mean has Euclidean distance

$set_p^{(i)} = \{a_p \big|\big| a_p - n_p^{(t)}\big|\big|^2 \leq \big|\big|a_p - n_j^{(t)}\big|\big|^2 \forall_j, 1 \leq j \leq c\}$, where a_p assigned one's and $s^{(t)}$ can be assigned to three or more cluster. In update step it calculates and observed new mean to be centroid in the new cluster.

3. Histogram based method

Histogram based analysis required one pass through pixel in satellite image. Histogram is computed according to all pixel and help to locate cluster in images. To measure image it can considered intensity and colour for input data. It helps in multiple frame adaptations in satellite image. Consider histogram based on pixel values$H_0, H_1, \dots \dots H_N$, here H_K define number of pixel with gray scale 'n' and 'k' which is maximum value of pixel. In first step guess has to be made

$\sum_{i=0}^{K} H_k \geq \frac{n^2}{2} > \sum_{i=0}^{k-1} H_k$, n^2 is number of pixels in n x n Images

In each category calculate pixel value of mean which is equal to or less than k.

Value less then and equal to denoted by $\mu_1 = \frac{\sum_{i=0}^{k} IH_i}{\sum_{i=0}^{k} H_i}$, if greater than 'k' it is given as $\mu_2 = \frac{\sum_{i=k+1}^{N} IH_i}{\sum_{k=i+1}^{N} H_i}$

Re-assign k between two mean as half way: $k = \frac{\mu_1+\mu_2}{2}$, Repeat above steps until k stop changing values

4. Expectation Maximization

Expectation maximization algorithm is used to determine maximum likelihood parameter of statistical model. It works as iterative model to find maximum posteriori (MAP) of parameters, which depends upon unobserved latent variable. For example it helps to find missing values exist on object which can be predicted using formula. Expectation maximization likelihood requires derivation of function with respect to unknown values of object with latent variables and parameters. It uses bit of misnomer. Its iteration increase data observation. It uses sequence converges of maximum estimator likelihood. It involved in liner maximizing function to drive expression of close form. It compute maximum priorities map to estimate Bayesian inference with object. It involves mean parameter and zero variance for same components for data points. Statistical modal generates 'i' set for observation data, the missing values 'x' and latent data set unobserved and 'θ' shows vector for unknown parameters with L(θ;i,x) = p(i, x / θ) likelihood function, maximum likelihood of parameters is defined with marginal likelihood for the given input data. L $(\theta; i) = p(i|\theta) = \int p(i, x/\theta) dz$, Sequence of event is denoted with 'x', it define object grows exponentially with length sequence and making sum calculation extremely hard. To estimate maximum likelihood it fallows two steps. First step is to find out expected value of function, with respect to 'x' conditional distribution under parameters $\theta^{(t)}$: p$(\theta|\theta^{(u)}) = E_{x|i,\theta^{(u)}}[\log L(\theta; i, x)]$, here maximization find the parameters for object $\theta^{(u+1)} =$ arg maximum $\theta(\theta|\theta^{(u)})$, $\theta^{(u)}$ denotes initial estimates.

It uses 'x' for latent variable which denoted memberships in groups. 1. Observed data 'i' may be continuous or discrete, associated with vector observation. 2. Missing value 'x' is discrete, for fixed number of values in object. For per observed unit, it uses one latent variable. 3. Parameters works under continuous order, it follows two conditions- Parameters associated with data point and latent variables.

Function given: K(R, $\theta) = E_p[\log L(\theta; i, x)] + H(p)$, q is arbitrary probability distribution, H(p) is entropy distribution with F(p, $\theta) = -D_{kl}(R||p_{x|i}(|i;\theta|) + \log L(\theta; i)$; $p_{x|i}(|i;\theta)$ is a conditional distribution of given data x, D_{kl} is kull back divergence, select q for maximization 'F', $q^{(u)} - \arg\text{maximum}\, R\, K(q, \theta^{(u)})$, select $\theta^{(u|1)} - \arg maximum\, \theta F(R^{(u)}, \theta)$.

Filtering and smoothing techniques

Filtering and smoothing technique used for minimum variance filtering and maximum likelihood calculations.

$$\sigma_x^w = \frac{1}{M} \sum_{i=1}^{M} (Z_i - \hat{p}_i)^2$$

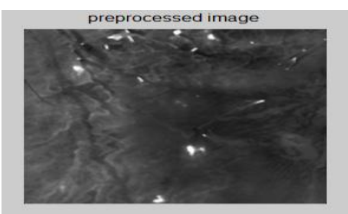
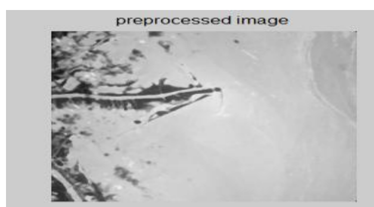
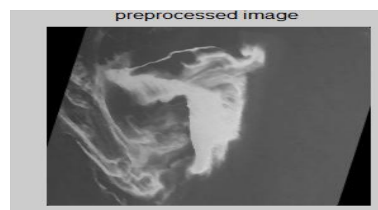
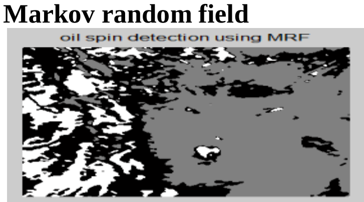
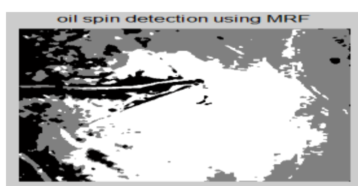
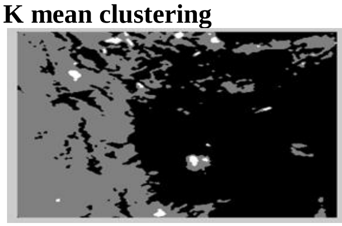
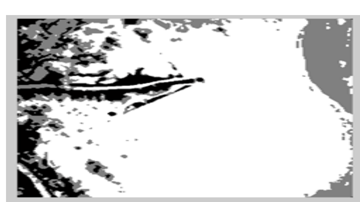
Where as $\hat{p}_k$ is scalar output value which is obtain by filtering and smoothing method.

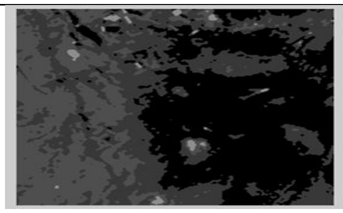
$\sigma_x^w = \frac{1}{M}\sum_{i=1}^{M}(p_{i+1} - \hat{f}\ \hat{p}_i)^2$, $\hat{p}_k$ *and* $\hat{p}_{k+1}$ is scalar values which is calculated using smoothing and filtering.

IV. RESULTS AND DISCUSSION

In this approach, four different techniques were used which helps to regular monitoring and detection of oil spills in the ocean. This research work is carried out using SAR RADARSAT-2 image. This technique examined SAR image to find structure of the oil spill with levels of gray corresponding to less damp / most damped area of sea surface roughness. Radar images confirmed grey level mask containing structure of the slick in Gulf of Mexico. Oil spill happened on 27 April 2010 where crude oil spread in 49,500 km2 across 19,112 square miles in Gulf of Mexico. As we know oil spill is one of the biggest issue in marine environment. Here four algorithms are applied to find out pattern, dark patches and tracking of oil spill with low time complexity in the given ENVISAT ASAR images. In this research different days images has been taken for regular monitor and observe occurrence of oil spill in ocean. For detection of oil spill incidence angle with HH polarization is suitable for research. According to HH polarization and incidence angles it helps to reduce noise which is created during bad weather conditions. For detection of spill ASAR width increase to 300km- 350km. Advance synthetic aperture radar provide high level of sensor images. Figure-3 indicates spills with patterns, dark patches, oil spill tracking and surrounding area of the images. To determine positive and negative pattern it compared with neighborhood pixels. In this paper after comparing four algorithms, it define expectation maximization techniques is more convenient and good for oil spill detection because in ASAR images it slowly varies gray level point based on image location and positions which help to monitor and detect oil spill region in fast way with low time complexity based on different weather condition. Expectation maximization algorithm is used to determine maximum likelihood parameter of statistical model. It works as iterative model to find maximum posteriori (MAP) of parameters, which depends upon unobserved latent variable. For example it helps to find missing values exist on object which can be predicted using formula. Expectation maximization likelihood requires derivation of function with respect to unknown values of object with latent variables and parameters.

Figure3. Oil spill Detection Results

		
Markov random field  Time taken for MRF 1.932765e+00 se	 Time taken for MRF 1.764280e+00 se	 Time taken for MRF 1.710396e+00 se
K mean clustering  Time taken 5.442832e-01 secs	 Time taken 5.794191e-01 secs	 Time taken 5.312782e-01 secs
Histogram based Segmentation		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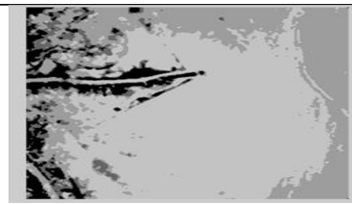
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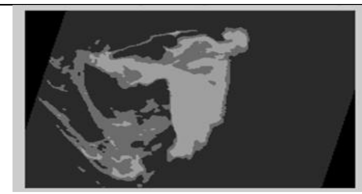
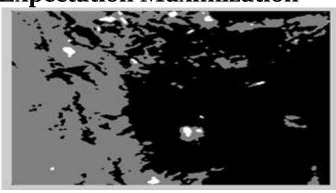

Time taken 6.292125e+00 secs

Expectation Maximization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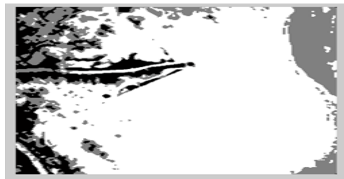
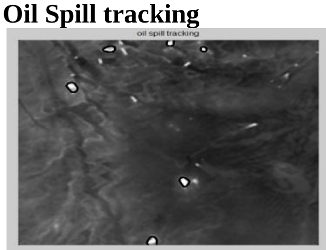
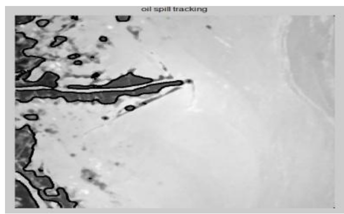
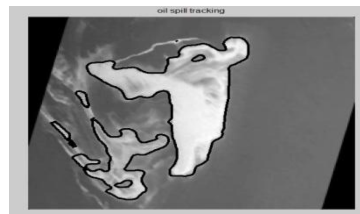

Time taken 3.014248e-01 secs


Time taken 2.558899e-01 secs

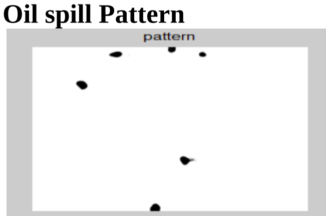
Oil Spill tracking

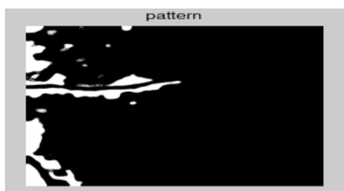


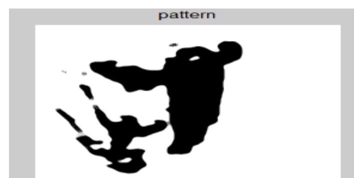




Oil spill Pattern

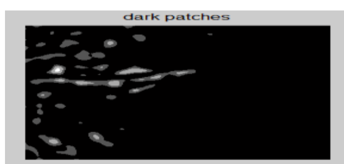






Dark patches

Area 3.561250e+02



Area 6.009575e+04

Area 1.209288e+04

Table2. Experimental Results for oil spill Detection Time

Techniques used	**Image 1**	**Image 2**	**Image 3**
Markov Random Field	1.932765e+00secs	1.764280e+00secs	1.710396e+00secs
K means clustering	5.442832e-01secs	5.794191e-01secs	5.312782e-01secs
Histogram based Segmentation	6.324111e+00secs	6.249907e+00secs	6.292125e+00secs
Expectation Maximization	2.767760e-01secs	3.014248e-01secs	2.558899e-01secs
Coverage Area (m^2)	3.561250e+02	6.009575e+04	1.209288e+04

V. CONCLUSION

Oil tanker collided in Gulf of Mexico on 27 April 2010 and spilled 3000 tons of oils in sea. The objective of doing this research work is to develop an oil spill detection techniques using Advance synthetic aperture radar images. Here three images were taken to observe the differences, patches, area and pattern of oil spills in Gulf of Mexico region. This research compares algorithms and find out which suited best for detection and monitoring of oil spills in ocean. After comparing algorithms, Expectation maximization is best suited for oil spill detection with less time consuming and ASAR play good sensors for research and development.

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