AUTO DETECTION OF OIL SPILL USING SATELLITE DATA SET IN GULF OF MEXICO

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ABSTRACT

This work focuses on oil spill detection based on satellite data set. Here a fuzzy clustering with Markov Random field technique has been proposed, which represents an important aspect for producing near real data using satellite based image for monitoring and change detection. The procedure are operated using Environment Satellite (ENVISAT) Advance Synthetic Aperture Radar (ASAR) data set in Gulf of Mexico. It determines unchanged and change region with Markov Random Field (MRF) energy function. In order to utilize Dark Spot, lookalike and patches, the membership of each pixel is modified where the modification determine by neighborhood pixel relationship, which can be done by least square methodology which reduce the effect of speckle noise. It consist four stages: 1) preprocessing of satellite image 2) generation of difference image(DI) from multi temporal image 3) analysis difference in satellite image 4) detection of dark spot and patches in SAR data. In this theoretical and experimental result detect real changes in oil seeping naturally from sea floor and occurrences carefully monitored. This experiment also shows low time complexity.

Key words: C Mean fuzzy clustering, detecting oil spill, MRF, satellite images.

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1. INTRODUCTION

The “release of oil in the ocean” is an alarming issue caused mostly due to man-made hazard, leading to the destruction of large area of flora and fauna. Today in national and international waters, oils are the most common and non dissolvable pollutant. Nearly million tons of oil in
miles of area pollutes the sea in a day. Mostly this oil pollutant comes from land like waste from cities, runoff water, unused or discarded oils of industries etc. One-third of oil pollution is caused by ships which are dumping their bilge water into the sea or by washing their tanks. Some other modalities of oil spills include collisions of ship, well blowouts, groundings, pipeline breaks, overfilling of gas tanks underground leaking of storage tanks, and during rain storms. Cleaning the oil from sea is a very challenging task. However, it can be controlled through combustion, solidifying, vacuum burning, skimming, adsorption, mechanical containment, and chemical dispersion. The oceanic transportation and distribution is also affected due to oil spills. In Mexico oil spill disaster occurred during spring 2010 that was the largest oil spill accident of marine world in the history. In the year 2010 around 1,00000 gallons of oil leakage were found in Gulf of Mexico, (Van Gerderen and Marghany, 2014). In September 19, 2010 and July 15, 2010 leak was stopped by engineers using gushing wellhead. Nearly 5 million barrels of oil were discharged it was officially considered (2014, Zhao et al). For viewing oil spill in sea water is quite difficult from human perspective but NASA provides information through satellite imagery which play vital role for detecting oil spill from sea bodies, with the help of satellite image we can identifies the oil spill status around sea and sea shore areas.

![Figure 1](http://www.iaeme.com/IJMET/index.asp)

**Figure 1** ENVISAT ASAR WS image, oil spill in Mexico

In [1], A.A. Alesheikh, N. Nouri & A. Ghorbanali proposed Coast line change detection using remote sensing in December 2007 and this approach, they proposed a combination of histogram and band ratio which produces the ground truth observation of an image there by finding the variation in coastline. In [2], 2014 Maged Marghany proposed an evolutionary in multi objective for detection of oil spill. In that proposed method COSMO Sky Med satellite data were used for pare to optimal solution which provide accurate pattern of oil slick with 96% of oil slick, 3% roughness of sea and 1% look alike. In [3], 2015, Maged Marghany, used Radarset-2 SAR, and Genetic Algorithm to automatically detect the oil slick footprint. In [4], 2016, Maged Marghany, proposed the receiver- operating characteristic curve to indicates presence of oil slick footprints. In [5], 2008, Maya Nand Jha, Yang Gao & Jason Levy, classified the application and characteristics of sensors. Here Scanning Laser Environmental Airborne Fluoro sensor (SLEAF) was used to detect oil spills.

In [6], 2010, Sonia Pelizzari and Bioucas Dias proposed Bayesian Segmentation of Oceanic SAR images to find out density of the observed backscattered signal. In [7], 2005, Abdul Duane Laval Matteo Ceriotti and Gianmarco Radice suggested space borne interferometric oil spill detection to define radar backscatter. In [8], 2008, K. Karantzalos and D. Argialas detected of oil spills with level set segmentation which track oil spills using SAR images. In [9], 2004, Camilla Brekke, Anne H.S. Solberh, September 2004, automatically distinguished between the look alike and oil slick based pattern.
2. DATA SET

In this study, ENVISAT ASAR WS acquired on 26 May 2010 with a dimension 346/258 km (215/160 miles), ENVISAT ASAR WS provide clear image with single pass. This satellite can produce either single or dual co and cross polarization image. Satellite image produces with multiple polarizations like VH, VV, HV and HH. It covers larger area for detection of change region. Due to regular monitoring it can detect real changes in marine environment.

![Image](https://example.com/image.jpg)

*Figure 2:* ENVISAT ASAR WS image with color composite (CCM), dimensions 346/258 km (215/160 miles), light gray appears as oil spill and light blue appears to features match to reference image.

3. METHODOLOGY

Let consider two co registered Synthetic aperture radar image: $i_1 = \{i_1(m, i), 1 \leq m \leq B, 1 \leq i \leq C\}$, and $i_2 = \{i_2(m, i), 1 \leq m \leq B, 1 \leq i \leq C\}$. Both size is $B \times C$ and $t_1$ and $t_2$. Then, mean ratio operator and log-ratio operator is applied to utilize Difference image represented by $iX = \{iX(m, i), 1 \leq m \leq B, 1 \leq i \leq C\}$. Then other task is difference image. The proposed method modifies each pixel membership based on Markov random field spatial context. Here in neighborhood pixel the pivotal energy function contained by spatial context. Here information provided by neighborhood pixels represented by spatial context. Figure 2. Shows Satellite Image Change Detection Block Diagram.

![Diagram](https://example.com/diagram.png)

*Figure 2* Satellite Image Change Detection Block Diagram

Step one take satellite images. Consider the overall dimension of two satellite image is $M \times N$. To generate difference in image apply MRO & LRO. MRO-Mean Ratio Operator, LRO-Log Ratio Operator, LMV-Local Mean Value, ALV-Absolute Logarithmic Value

$$MRO = 1 - \min \left( \frac{E_1}{F_1}, \frac{E_2}{F_2} \right)$$  \hspace{1cm} (1)

$E_1$ & $E_2$ Represent LMV & $F_1$ & $F_2$ Represent ALV, MRO- Find out image difference, LRO-Covers large area and enhances low intensity pixel values. Apply MRFFCM algorithm, In
step 1 the iteration k=1, mean =\( \mu^1_t \) & SD =\( \sigma^1_t \), to built (EN) energy function \( E^k_{ij} \) using for kth iteration. To compute the point wise prior probability matrix(\( \pi^k_{ij} \)) here Gibbs expression were used.

\[
\text{probability matrix} = \frac{\exp(-E^k_{ij})}{\exp(-E^k_{ij}) + \exp(-E^k_{ij})}
\] (2)

Determine probability based on conditional (\( p^k_{fi} \)) then compute (DM) matrix of distance (\( d^k_{ij} \))

\[
p^k_{fi} = \frac{1}{\sigma^k_t \sqrt{2\pi}} \exp \left[-\frac{(y_x - \mu^k_t)^2}{2\sigma^k_t} \right]
\] (3)

\[
d^k_{ij} = -1n \left[p^k_{fi} \left( \frac{y_x}{\mu^k_t, \sigma^k_t} \right) \right]
\] (4)

Calculate objective function using \( j^k_{ij} \)

\[
d^k_{ij} = -1n \left[p^k_{fi} \left( \frac{y_x}{\mu^k_t, \sigma^k_t} \right) \right] |j^k_{ij} - j^{k-1}_{ij} | \leq \delta
\] (5)

Membership new matrix can be generated using \( \{\mu^k_{ij}\} \)

\[
\mu^k+1_{ij} = \frac{\pi^k_{ij} \exp(-d^k_{ij})}{\pi^k_{ij} \exp(-d^k_{ij}) + \pi^k_{ij} \exp(-d^k_{ij})}
\] (6)

Now Mean and standard value must be updated as \( \mu^k+1_t \) and \( \sigma^k+1_t \) respectively, \( k=k+1 \)

\[
\mu^k+1_t = \frac{\sum_{j \in I_x} (u^k_{ij} (y_j - \mu^k_t))^2}{\sum_{j \in I_x} (u^k_{ij})}
\] (7)

\[
\sigma^k+1_t = \sqrt{\sum_{j \in I_x} (u^k_{ij} \left( y_j - \mu^k+1_t \right)^2})
\]

4. EXPERIMENTAL RESULTS BASED ON SATELLITE DATA SET

Result shows in two ways: first is finding final binary map and other is to provide some values which evaluate binary maps. In this approach first count the number of overall pixels which is denoted by N then based on binary map, count number of unchanged and change region of pixels to find out actual number of pixel representation. Other hand the reference map will be compared with the generate image point by point. Based on this an accurate number of pixels can be classified according to change and unchanged classes and they are represented as \( F_N \) and \( F_P \) respectively.

\[ N_{C-F_N}=TP \]
\[ N_{U-F_P}=TN \]

Whereas TP- True Positive and TN- True Negative, which represent change and unchanged pixel correctly. To evaluate father, PCC (Percentage Correct Classification) was considered which determine correct rate of pixel values.

\[ PCC=\frac{TP+TN}{N} \]

In common place ‘N’ shows larger values so it is very difficult to identify similarity between two or more facts. To overcome this situation (OE) overall error is introduce.

\[ FP + FN = OE \]

For over all evaluation kappa coefficient (Kc) is applied, which effect result in image segmentation, if the value is higher in Kc then segmentation result will be much better.
Whereas

\[ K_c = \frac{PCC - PRE}{1 - PRE} \]

Whereas,

\[ PRE = \frac{(T_p + F_p)N_c + (F_n + T_n)N_u}{N} \]

Kc ranges in between ‘0 and 1’. In this approach Kc depend on sum values of TN and TP. Therefore PCC is less co-efficient than KC because of more classification information. Here time is also an important factor, which denoted as ‘T’ counted in seconds. The experiment result represents less time complexity. The value of evaluation criteria is displayed in the form of table.

Table 1 Value of Evaluation Criteria

<table>
<thead>
<tr>
<th>Image description</th>
<th>Technique</th>
<th>FP</th>
<th>FN</th>
<th>OE</th>
<th>PCC</th>
<th>Kc</th>
<th>T/S</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENVSET ASAR WS</td>
<td>MRFFCM</td>
<td>354</td>
<td>49</td>
<td>415</td>
<td>0.99</td>
<td>0.83</td>
<td>70</td>
</tr>
<tr>
<td>Gulf of Mexico</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Image</td>
<td></td>
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</tr>
</tbody>
</table>

Figure 3 (a) Log ratio operator,(b) Mean ratio operator,(c) Reduction of background noise (d) Ground truth image for the particular dataset.

Figure 4

Figure 5

Figure 4 Represents Oil spill detection based on MRFFCM and figure 5 shows MRFFCM Algorithm which used to generate histogram image of the given data set. Here three functions were used oil spills, sea roughness and water content.

5. CONCLUSIONS

This study demonstrated oil spill detection based on satellite data set. Here a fuzzy clustering with Markov Random field technique has been proposed, which represents an important
aspect for producing near real data using satellite based image for monitoring and change detection. The procedure are operated using ENVISAT ASAR data set in Gulf of Mexico. It determines unchanged and change region with MRF (Markov Random Field) energy function. In order to utilize Dark Spot, lookalike and patches, the membership of each pixel is modified where the modification determine by neighborhood pixel relationship, which can be done by least square methodology which reduce the effect of speckle noise. It consist four stages- preprocessing of satellite image, generation of difference image (DI) from multi temporal image , analysis difference in satellite image and detection of dark spot and patches in SAR data .In this theoretical and experimental result detect real changes in oil seeping naturally from sea floor and occurrences carefully monitored. This experiment also shows low time complexity. It determines oil spills from national and International water sources by using satellite input data. It provides informative details, by reducing incidental of oil spills by giving bulk factors and these factors, make easy to recover oil spills and minimize the problems. So that any researchers and research organization can easily solve issues related to oil spillage. This approach can detect problem related to oil spill, fast clear-up operation, prevent environmental problems and by regular monitoring of spillage can solve up-coming problems.

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REFERENCES


