COMPARISON OF TWO ALGORITHMS TO IMPROVE THE DETECTION OF OIL SPILLS

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KEYWORDS: oil spill, SAR, algorithm, ecosystem, image processing.

ABSTRACT

This paper will present the art of detecting oil spills in the ocean by using synthetic aperture radar (SAR) sensors carried by Radarsat-1. Recently, there has been widespread media coverage of the tremendous damage caused by oil spills. The detection of oil spills in (SAR) images in the last decade has been discussed through various researches in terms of wind situations, tools used to detect oil spill, difficulties facing operations to discriminate oil spills from other occurrences. Moreover, we will highlight the procedure of detecting and image processing used to avoid false alarm. In addition, the comparison in this study will be based on two algorithms to show the suitable one in terms of image processing. The result shows that Mahalanobis distance D used to identify deviant members of the sample one in terms of lake ancillary information agreed with some studies done before such as (Brekke and Solberg, 2010; Topouzelis, 2008 ; Perumal and Bhaskaran 2010).

Introduction

Oil spills can cause a lot of distress to the affected communities. It is important that oil spill response actions are explained to everyone involved, including those likely to be worst affected by the oil spills. The effect of oil spills has been seen in different regions in the recent decade due to the development in the lifestyles of modern nations and the subsequent consumption of oil has increase rapidly and thus affected the environment. Each year, tanker accidents contribute 5% of all pollution entering into the sea. On the other hand, 48% of the oil pollution in the oceans is due to fuels and 29% as a result of crude oil (Fingas, 2001; Brekke and Solberg, 2005). Larger oil spill accidents like the Prestige Vessel accident in 2002 can be a less threat to the marine environment and the ecosystem than the deliberate oil spill caused by tank cleaning or irregular disgorges, particularly for the countries use the tourism sector as the main income for the economy such as Malaysia. By taking into account how frequent such spillages occur yearly, we can recognise that controlled irregular oil spills by using remote sensing tools will boost the protection of environment (Brekke and Solberg, 2005; Assilzadeh and Mansor, 2001). Some oil spill accidents which occurred over the last decade such as some vessel accidents which have contributed to oil spills from 1989 until 2002, have affected the ecosystem Table (1) below gives a brief explanation of the major oil spills from 1989 to 2002 based on the date, size and name (ITOPF, 2010). Recently, an accident happened in Malaysia between tanker MT Bunga Kelana 3 and St Vincents on 26 May, 2010that causes oil spill of about 2,500 tonnes of crude oil. (ITOPF, 2010)

Table 1: Major oil spills since 1989.

No:	Ship name	Year	Location	Spill Size (tonnes)
1	Exxon Valdez	1989	Prince William Sound, Alaska, USA	37,00
2	Abt Summer	1991	700 nautical miles off Angola	260,00
3	Haven	1991	Genoa, Italy	144,00
4	Aegean Sea	1992	La Coruna, Spain	74,00
5	Sea Empress	1996	Milford Haven, UK	72,00
6	Prestige	2002	Off Spanish coast	63,00

Oil slicks produce distinctive remote sensing signatures detectable by Synthetic Aperture Radar (SAR) Satellites like RADARSAT-1, ERS1, ERS2, ENVISAT, JERS, and the newest generation of SAR systems like RADARSAT-2 and Terra SAR-X. Part of the emitted radar energy (5.6 cm wavelength) directed at the ocean is reflected back to the satellite because of the roughness of the sea surface and is imaged as a gray speckle (MacDonald, I., et al. (1996). When the sea is smoothed by viscoelastic properties of an oil slick or any other surfactant, the energy from the radar is reflected away from the sensor, reducing the radar backscatter and producing a dark area on the image. According to Alpers, and Huhnerfuss (1998 a) and Alpers and Huhnerfuss (1998b), the Marangoni damping theory that it occurs based on the presence of oil film on the sea surface damps these kinds of waves because of the resonance-type behaviour of the viscous elastic surface films**.**

In the studies, researchers propose procedures to detect oil spills in SAR images by using the image comparison technique. To improve the SAR image, the image is prepared by using some image enhancement techniques, such as the median filter, algorithms used for automatic detection that can help in screening the images and prioritising the alarms which will be of great benefit (Tsai ,1989). Research in this field has been ongoing for more than a decade, and this paper reviews two algorithms - Mahalanobis and Median - for satellite-based oil spill detection in the marine environment after doing some procedures to enhance the images, as SAR is just one of many remote sensing sensors available (Brekke and Solberg, 2005). In summary, SAR is still the most efficient and superior satellite sensor for oil spill detection. On the other hand, it does not have the capabilities for oil spill thickness estimation and oil type recognition. SAR is useful particularly for searching large areas and observing oceans at night and cloudy weather conditions. In addition, there are some limitations, as a number of natural phenomena can give false oil spill detections. Additionally, SAR is only applicable for oil spill monitoring in a certain range of wind speeds. Wind level influences the backscatter level and the visibility of slicks on the sea surface (Gade et al, 2000). From this, we can absolve that any algorithm should take the vector of wind speed into account to avoid false alarm. Mahalanobis has been used in the different studies and gives a good result to detect oil spills in the sea surface from other phenomena based on the neighbour pixel, so it is the same idea of Median algorithm except that Mahalanobis needs to identify the variation which will be explained in terms of the results.

Study area

The study is carried out along the Malacca Straits coastal waters between the Strait of Malacca which is located between the east coast of Sumatra Island in Indonesia and the west coast of Peninsular Malaysia, and is linked with the Strait of Singapore at its south-east end. Figure 1.1a, b, c d and e shows the different sides of the Malacca Straits coastal line with suspected dark areas.

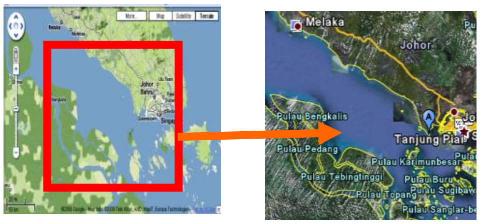

Figure1.1 a: Tanjung Piai, Johor

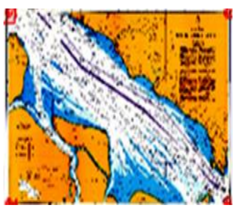

Figure 1.1c hydrographic chart

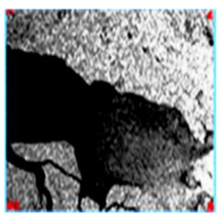

Figure1.1 b: Tanjung Piai, Johor

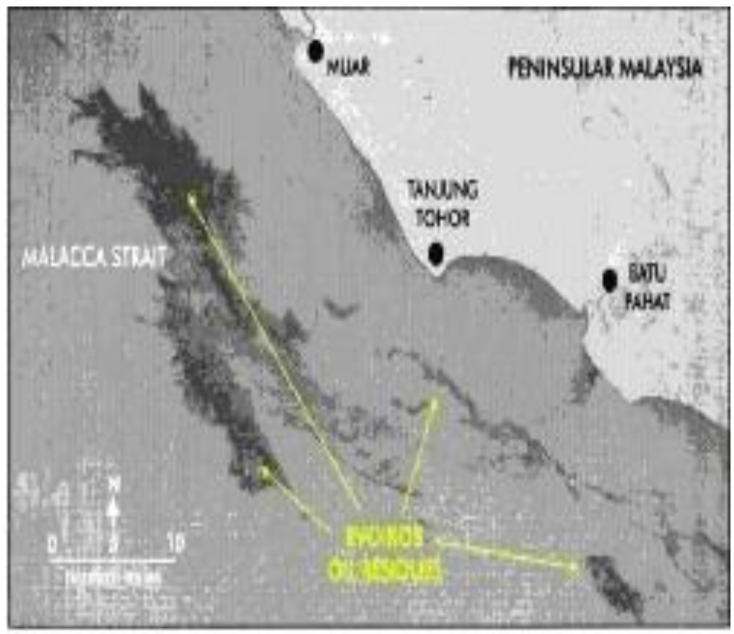

Figure 1.1e: Radarsat data locates of suspected oil slicks

Methodology

Pre-processing in radar images include Antenna Pattern Correction (APC), Radiometric Correction and Geometric Correction. These can be applied to prepare the SAR images precisely. Antenna Pattern Correction (APC) performs a radiometric balancing on Synthetic Aperture Radar (SAR) data to compensate a non-uniform illumination in the range direction due to the antenna pattern (Maged et al., 2009). The acquired data was geo-coded automatically using ENVI software.

Single to Noise Ratio (SNR) is estimated. In fact, SNR is able to relate between the mean and the degree of detection between the gray level and its mean value for the overall image. According to Nasir (2004), the SNR can be estimated using the following formula:

$$SNR = \mu / \sigma \qquad (1)$$

where μ is the mean value of image intensity while σ is the standard deviation of SAR image intensity. Median filters will smooth an image, while preserving edges larger than the kernel dimensions (good for removing salt and pepper noise or speckles). The Median filter replaces each centre pixel with the median value (not to be confused with the average) within the neighbourhood specified by the window size 3x3 kernel. The formula, as explained below, identifies the dark area as the oil spill due to the ability of the algorithm to provide the result as shown in the figure 2 after using the Median algorithm. Each centre pixel with the median value within the specified neighing means the dark pixel indicated

the oil spill in terms of the relationship between the pixel neighbourhoods. Deterministic and statistical properties of median filters are therefore used to describe the filter's effect on noisy signals. In a recent publication, the author has studied the functional optimisation properties of median-related filters such as Samad & Mansor (2000). Thus, by considering the edge detection by using the main formula of Median Filter, which is considered as an adaptive filter, noting where one component measures the smoothness between the filter output and its neighbourhood points within the filtering window and the other measures the discrepancy between the filter output and the original signal at that particular point. (Qiu, 1996). The figure (2) below shows the result of the Median Filter:
y(n) = med[y(n - m), y(n - m + 1),…, y(n - 1), x(n), …. , x(n + m)] (2)

Mahalanobis distance D is used to identify deviant members of the sample. Its square is defined by:

$$D^2 = (x_m - \bar{x})' s^{-1} (x_m - \bar{x}) \qquad (3)$$

Mahalanobis distance (or generalised squared inter-point distance (for it is square value) can also be defined as a dissimilarity measure between two random vectors $\vec{x}$ and $\vec{y}$ of the same distribution with the covariance matrix S:

$$d = (\vec{x}, \vec{y}) \sqrt{(\vec{x} - \vec{y})^{st-1} + (\vec{x} - \vec{y})} \qquad (4)$$

In order to apply Mahalanobis's classification procedures to different remote sensing data, let **x** be the feature vector for the unknown input, and let **m**1, **m**2 be the two classes: oil spill, and look-alike. Then the error in matching **x** against m j is given by [x- **m** j], so A minimum-error classifier computes [x**m**j] for *j*= 1 to 2 and chooses the class for which this error is minimum.

Results and Discussion

The study concludes that from the visual interpretation analysis, several patches and linear dark slicks located at the centre of the Straits of Malacca and wide dark slicks that are located near the coast and at the centre of the Straits of Malacca were found to be confusing between oil spills and natural phenomena that dampen the short waves and create dark patches on the surface. Natural dark patches are termed oil slick look-alikes, so by using Mahalanobis, the identification of oil spills will concentrate on two classes only - either oil or lookalike in terms of different variations between oil spills and lookalikes as shown in Figure (3) by using the Median adaptive algorithm will reduce the effect of "salt and pepper” and smooth the image without affecting the edge as shown in Figure 2.

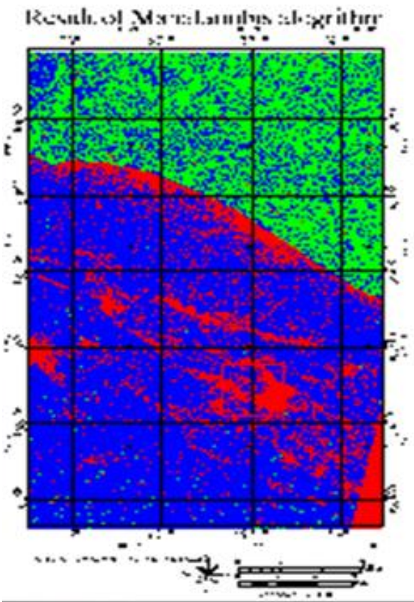

Figure 3 shows the oil spill clearly by red colour

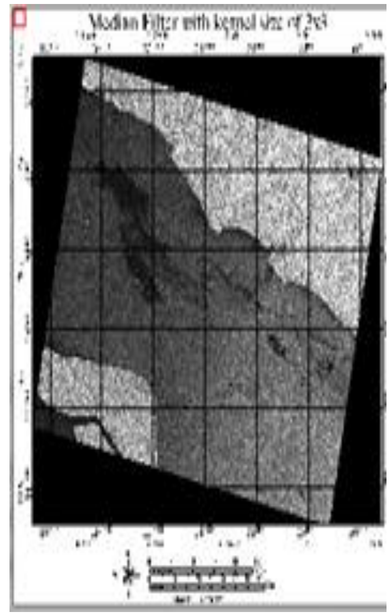

Figure 2 shows the edge of each element of the image

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