Oil Slick Spot Detection Using κ-distribution Model of the Sea Background

Hong-zhong Li[1,2], Chao Wang[1], Hong Zhang[1], Fan Wu[1]

[1]Center for Earth Observation and Digital Earth Chinese Academy of Sciences, Beijing, China

[2]Graduate University of Chinese Academy of Sciences, Beijing, China

Email: hzli@rsgs.ac.cn

ABSTRACT

Oil spills appear as dark areas in synthetic aperture radar (SAR) images because the oil damps the short gravity waves on the sea surface. The detection of oil spills has three steps: (i) detection of dark spots; (ii) feature extraction; and (iii) dark spot classification. The dark spot detection locates all spots which can possibly be oil slicks in the image. For each slick, a set of backscatter textural and geometrical features are extracted. The dark spots are then classified into possible oil slicks and "look-alikes" based on the extracted features.

Lots of researches have been carried out for the third step--distinguish oil spills from "look-alikes", while few researches for the first step--dark spots detection, the base for the oil spill detection. The single threshold[4]--one half of the average NRCS for the sea area had been shown performing not well in segmenting both large and small regions. The adaptive threshold[2,3,5] is based on an estimate of the typical backscatter level in a large window, k dB below the estimated local mean backscatter level, and wind data (the wind level) is used to determine k. When we have no wind level information of the oil slick region, the adaptive threshold is not applicable. The two peaks[2] method is based on the image histogram. The histogram contains two peaks, the lower is located around the mean backscattering value of the dark object, the taller around the mean value of the background. The local minimum value between the peaks is stored and is the one used for image fragmentation. While if the oil slick region diffused to large areas, the two peaks are not distinguishable, and the fragmentation threshold can't be gained.

In this paper, an oil slick spot detection approach using κ-distribution model of the sea background is presented. As we know, κ-distribution is a suitable probability density function (PDF) for RADARSAT and ERS ocean scenes. Obviously the oil slicks break the PDF, diminish the mean value of the whole region and turn the pixel value having the maximum probability to a lower one. Luckily, as the oil slicks just darken parts of the sea areas in image, the relative probability ratio among the pixel values larger than the maximum one have not changed. The main idea of the approach is to deduce the κ-distribution model of the sea background using the unchanged relative probability ratio, and get the fragmentation threshold by comparing the two PDFs—the original one and the deduced one.

κ-distribution model has 3 parameters, mean value $< I >$, shape parameter γ, and the number of statistically independent looks L.

$$p(I) = \frac{2}{I\Gamma(\gamma)\Gamma(L)}\left(\frac{L\gamma I}{< I >}\right)^{\frac{L+\gamma}{2}} K_{\gamma-L}\left(2\sqrt{\frac{L\gamma I}{< I >}}\right)$$

Obviously, L has not changed, and the shape parameter γ is presumed unchanged—calculated from the original image. So the parameter what we should deduce is only the mean value $< I >$. The major steps are shown as follows:

Step 1 Suppose the pixel value with the maximum probability in κ-distribution is $\hat{I}$, then $p'(\hat{I}) = 0$, where $p'(\hat{I})$ is the differential at $\hat{I}$. Solve the differential equation, get the parameter $< I >$ and an estimated κ-distribution model.

Step 2 Compare the relative probability ratio among the pixel values larger than $\hat{I}$, check the consistency between the estimated κ-distribution model and the original one of the oil slicks image. If consistent, regard the estimated κ-distribution model as the one of the sea clutter, otherwise, $\hat{I} = \hat{I} + 1$, and repeat the step 1.

Step 3 Store the intersection point of the estimated κ-distribution model and the original one of the oil slicks image and use the value for image fragmentation.

The advantage of the method is independent of wind data and hence it can detect the oil slicks spot without the wind level information. This method is validated for the RADARSAT and ERS data.

Index Terms--- oil spill detection, κ-distribution, sea clutter,

REFERENCES

[1] C. Brekke and A. H.S.Solberg, Classifiers and Confidence Estimation for Oil Spill Detection in ENVISAT ASAR Images. IEEE Geoscience and Remote Sensing Letters, vol. 5,no.1,pp.65-69 Jan. 2008

[2] F.Del Frate, A. Petrocchi *et.al.* Neural Networks for Oil Spill Detection Using ERS-SAR Data, IEEE Transactions on Geoscience and Remote Sensing,vol.38,no.5,pp.2282-2287,Sep. 2000

[3] A.H.S.Solberg, C.Brekke *et.al.* Oil Spill Detection in Radarsat and Envisat SAR Images, IEEE Transactions on Geoscience and Remote Sensing, vol.45,no.3,pp.746-756,Mar.2007

[4] B.Fiscella, A.Giancaspro *et.al.*, Oil Spill Detection using Marine SAR Images, INT.J.Remote Sensing,vol.21,no.18,pp.3561-3566,2000

[5] A.H.S.Solberg, G.Storvik *et.al.*,Automatic Detection of Oil Spills in ERS SAR Images, IEEE Transactions on Geoscience and Remote Sensing, vol.37,no.4,pp.1916-1925,July 1999

[6] L.J.Shi,C.F.Zhao *et.al.*,Texture Feature Application in Oil Spill Detection by Satellite Data, Congress on Image and Signal Processing 2008