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Classification and Detection of Oil Spills Using Artificial Neural Network (ANN)

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Abstract: Oil spills represented a greater threat to marine ecosystem and their health. From the recent incident in the Gulf of Mexico, the adverse effects of oil spills on the nature are imminent. Synthetic Aperture Radar (SAR), a high resolution remote sensing imagery, can be effectively used for the detection and classification of oil spills. Pollution caused by Oil spills may appear as dark spots in SAR images. However, these images may contain numerous contents which very closely might resemble to oil spill area, resulting in misidentification. The main aim of paper is the development of algorithms to distinguish oil spills from 'look-alikes. This paper, with the help of two different Artificial Neural Networks (ANN), describes the development of a new approach to SAR oil spill detection. The first ANN identifies the pixels of a SAR image belonging to candidate oil spill features. The second ANN, on the basis of the feature parameters, classifies objects into oil spills and their look-alikes.

Keywords: Artificial Neural Network, Synthetic Aperture Radar (SAR) imagery, Edge detection, Adaptive thresholding, Image segmentation.

I. INTRODUCTION

Beneath the surface of our planet, Earth, are huge reserves of oil and gas. Occasionally, the earth's crust corrodes and develops cracks from which these oils and gases leak into the environment. However, when this happens it is a part of nature and rarely causes any major damage. On the contrary, when the same problem is caused because of human interference, it can cause a great deal of damage to marine ecosystems. In the recent years, the issue of oil spills and their effects has taken on much importance. Occurrence of oil spills causes a multiple problems for the environment and us.

Oil spills result from intentional and unintentional sources and both of them have an adverse effect on the environment. The marine life or life near the shore is the ones most affected by the spill. These oil spills either choke the animals to death or causes vital problems to the animals. The oil sticks to the fur and plumage of the animals and as a result, marine animals find it harder to float in the water or regulate their body temperatures.

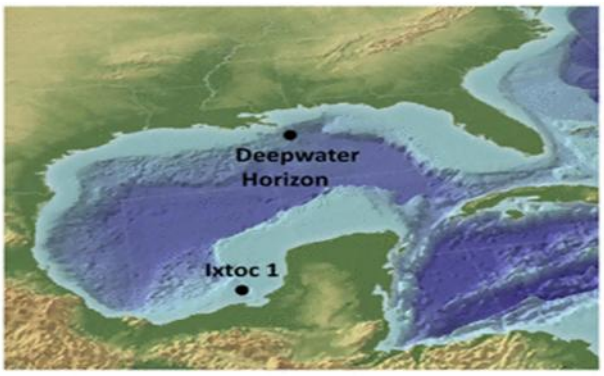

Fig. 1 The Gulf of Mexico in 3D perspective indicating the location of the two marine blowouts. *Source*: NOAA (http://oceanexplorer.noaa.gov/technology/tools/mapping/media/gis_gulf.html)

Europe provides the world's largest market for crude oil imports, representing about one third of world's total. Unfortunately, some of this oil makes its final way to the sea as most of the times the transportation is done by water ways. One of the biggest oil spills seen in history happened during Gulf war. It was considered one of the worst disasters, beating the Ixtoc 1 Oil spill in Mexico.

Although many cost effective oil spill detection satellites are been made but they possess their own disadvantages. Most of the times these oil spill detections devices cannot discriminate between the actual oil spills and the surrounding sea. Also for devices with Synthetic Aperture Radar (SAR) sensors, detection of spills at night or in bad weather conditions is difficult. A typical SAR-based oil-spill detection process consists of three stages: image segmentation, feature extraction and classification. Through a binary classification of image pixels, the segmentation stage detects and identifies the candidate features within the image taken from the SAR imagery. After extracting these features from the segmented image a feature dataset is formed. This feature dataset is also considers the derived quantitative description of shape and form of each feature. Finally, the classification stage, on the basis of this feature dataset, distinguishes oil spills from its look-alikes.

II. LITERATURE REVIEW

The paper presents the advanced technique for oil spill detection in oceans worldwide. Author will discuss various satellite sensors and oil spill detection under changing conditions. Particularly, Author focuses on the use of automated and manual ways to differentiate between oil spills and look alike, this is done on basis of pattern recognition. [1]

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Extraction of edge-end-pixels is an major step for the edge linking process, which is done to achieve edge-based image segmentation. Algorithm presented in this paper to extract edge-end pixels together with their directional sensitivities is an extension to the currently available mathematical models. The algorithm is implemented in the Java environment since it has compatibility with web interfaces. Its main use is thought to be for remote image analysis, on a virtual instrumentation platform. [2]

This paper presents segmentation-based algorithm for oil spill feature extraction from Synthetic Aperture Radar (SAR) images. By segmenting a scene covering an oil spill and/or look-alikes into two homogenous regions: dark spots and their marine surrounding, the shape and distribution features of dark spots can be achieved. The proposed algorithm is applied continuously at many real SAR images and simulated SAR intensity images which are used for accurate evaluation. The results depict that the new algorithm can extract the shape and distribution parameters of dark spot areas, which are useful for recognizing oil spills in a further classification stage. [3]

III. METHODOLOGY

i. Input Data Source:
Using 62 C bands VV polarized ERS-2 SAR and ENVISAT ASAR images obtained from the European Space Agency. 48 images contained oil spills and 14 contained look-alikes.

ii. Dark Spot Detection:
Preprocessing is done before designing an algorithm to identify oil spill, to find what makes the oil spills to look unique. This is done to sample out the oil, water and land. Ocean water appears blue, cloud appears white; land covered by vegetation looks green. While checking the images, the colors change for oil, water and the land. The color of an image is represented by three values for red, green and blue components. Color images can be threshold. First way is to assign a separate threshold for each of the RGB components of the image and then combine them with an AND operation. This is according to the way the camera works and how the data is stored in the computer. But it does not correspond to the way that people recognize color. The dark object detection involves image segmentation.
The image segmentation was performed using the new ANN technique and two new techniques: edge detection segmentation and adaptive thresholding. For Each SAR image, training areas corresponding to the background were selected. The ANN architecture was then changed by adding hidden neurons and then comparing the resulting effect on the accuracy of image segmentation. Using the test data set, a hidden layer of four neurons was selected as optimal.

iii. Edge Detection:
Image thresholding by the variance and implementing the dark spotted boundary around the main affected area is done using this method. The differences between the neighboring pixels show the color value differences indicating to the oil spills. In the oil spill areas, the RGB ratio will be different from the non-affected areas. It gets highlighted and surrounded with black spots. For minor affected areas, the edge detection may not be applied.

iv. Feature Extraction:
The output of the segmentation stage is a binary image which separates dark objects from the background. In next stage of the algorithm there is the generation of a vector of features. It quantitatively describes relevant characteristics of the object, including shape, texture, and shape as well as backscattering attenuation. After the segmentation stage the binary images obtained are processed to derive the boundaries of each object. Pixel data are identified within and outside each object boundary and then used to compute the corresponding feature vector.

v. Feature Classification:
In SAR images, dark spots can be created by a number of reasons. The main aim of the classification process is to differentiate between oil spills and look-alikes. An ANN is used regularly for automatic classification algorithms. Neural network is a mathematical model made of many neurons operating parallel. The input is feature of vectors which are extracted from dark spot segmentation.
During the final processing stage, a second ANN based classifier is used to differentiate between oil spills from lookalikes. It is based on the fourteen-element feature vector, describing each dark object. Many different combinations of training set, testing set and neural network training parameters such as momentum factor, learning rate and number of epochs should be implemented to optimize classification accuracy. Three different training sets were constructed. Each training set contains an equal number of randomly selected feature vectors from each class (oil spill and look-alike examples) making sure equal representation in the training set and unbiased training.

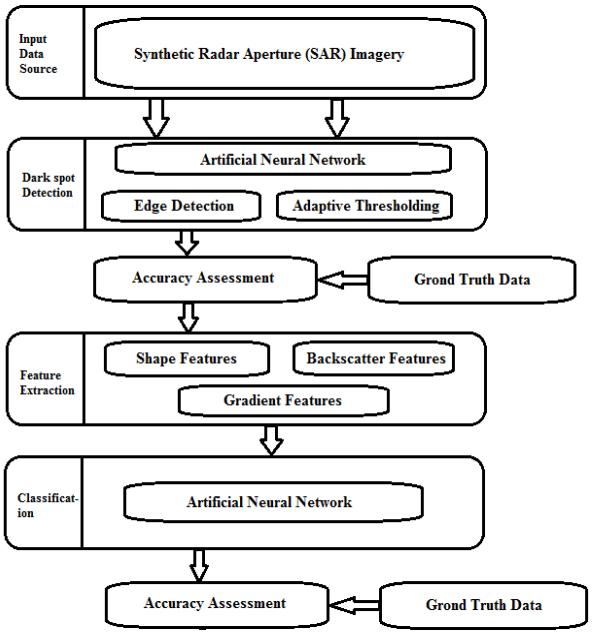

Fig. 1: Methodology Block Diagram

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IV. PROCESS

Consider the following image for instance to undergo the morphological methods.

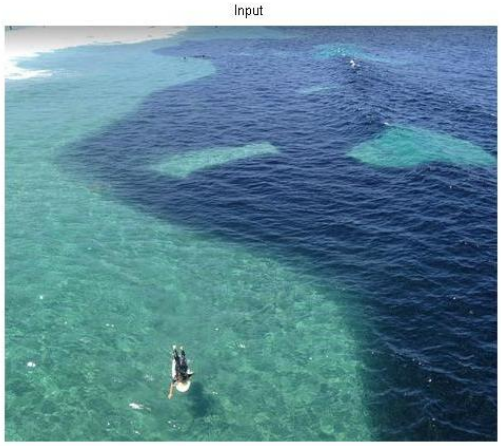

Fig. 2: Input image

After undergoing the morphological processing, we get output as the following images:

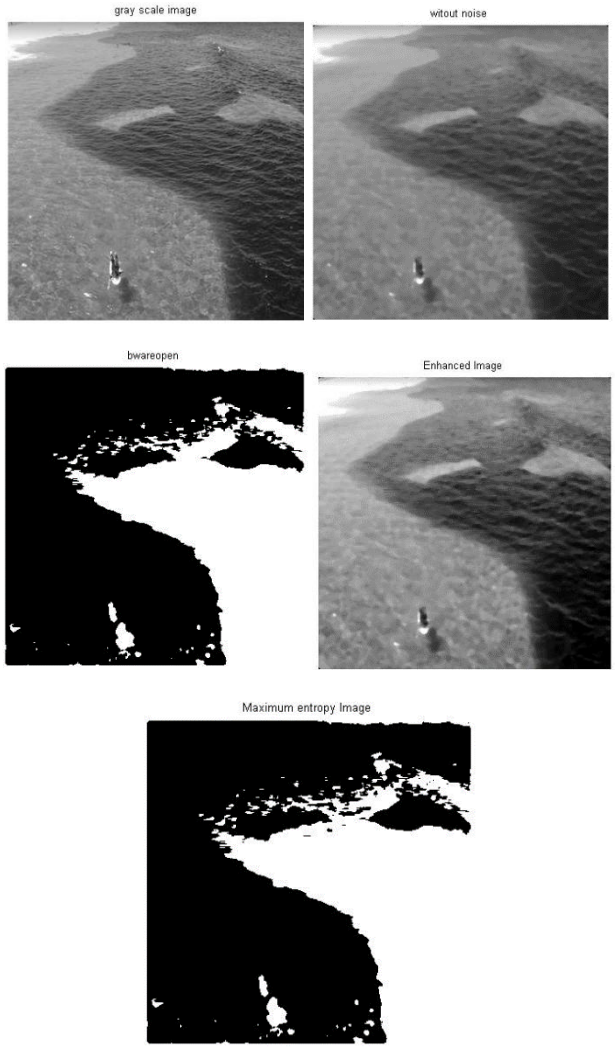

Fig.3: Images obtained after segmentation

V. CONCLUSION

In this paper, the analysis of the current situation related to oil-spill detection and classification systems is given from a technical (i.e. image processing and data fusion) and operational (i.e. follow-up and law enforcement) points of view. In this paper, the demonstration focuses on a new oil spill classification system. This classification system uses two neural networks, one for image segmentation and the second one for feature classification. It was found that the performance of the neural network segmentation stage is better than both other methods namely- edge detection or adaptive thresholding. The performance of the gradient features in the classification stage is significant and these features specifically deserve attention in future research

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