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Fuzzy Logic Technique for Oil Spill Monitoring in Disaster Management and Response in Ocean Using Satellite Data

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Abstract

Background: In this research work the Fuzzy Logic algorithm was examined to identify the occurrence of an oil spill in the ocean. The oil spill is considered the biggest issue in the world. Every year a large number of oil spills incidence happens due to human activity this is done due to human-made disasters through transportation services. In this research work, two stages have been examined to identify the occurrence of the oil spills using SAR data. Oil spreading is a dangerous issue in the marine world because most kinds of oil are less dense than the water, maximum spilled oil floats on the water surface body. It spread out and pushed in water through currents and winds. After splitting into the sea within 10 minutes, 300 hundred gallons of oil can spread across 160 feet and develops slick 4th inch deep. After that, based on water surface tension it determines how far and fast oil gets spreads. Its only depends on how much molecular in water are attracted to each other. So it is very necessary to regularly monitor oil spills.

Methods: In this research work, the Fuzzy Logic technique was investigated for the detection of oil spills disaster in the ocean. This investigation is divided into two stages: The first stage is the detection of the oil spill and the Second stage is tracking oil spills using consecutive SAR data.

Results: The study demonstrates that the Fuzzy Logic Algorithm can be used as a good tool for oil spill detection and tracking using satellite images. In result, it is denoted as a fuzzy logic algorithm can be used as a good tool for tracking oil spill using satellite image with a highest covering spilled area over the ocean.

Keywords : Satellite Image, Oil Spills, Fuzzy Logic, Tracking, Detection.

1. INTRODUCTION

Oil spreading is a dangerous issue in the marine world because most kinds of oil are less dense than the water, maximum spilled oil floats on the water surface body [1]. In this research Synthetic Aperture Radar image has been used which play a very important role in monitoring because it produces a high-resolution image, in which successive pulse of a radio wave is transmitted to electromagnetic waves to sequentially reflected and transmitted by radar antenna for continuous monitoring of oil spills, which helps in the sample under test [2,3 4]. Oil spills are different types such as class A, B, C, D, and non-petroleum oil. Oils of class A are light based higher quality “crude oils” and products refined and produce as jet fuel and

gasoline which disappear fastly and affect the marine life. Gasoline includes toxic components such as benzene known hexane and carcinogen, which damage animals and human life systems [5, 6,7]. Class B oils are crude oils with lower quality, example heating oils and kerosene oil. Crude oil with lower-quality light and refined products oils will burn longer and highly flammable than class A oils. It is also called as "non-sticky" oils. The non sticky oils are low in toxification and more adhere on surface. According, Wildlife and Fish Service, the U.S., cause long-term contamination. Class C oils are sticky are heavy [8,9,10]. Class C oil, will not penetrate or spread quickly in the soil and they do not easily disperse and dilute. Class D oil is the solid crude oil and they are less toxic [11]. Class D oil occurs when it gets heated and hardens on the surface, which makes nearly impossible to clean up. Oils derived from animal or plant and Synthetic oils, fats are regulated easily[12,13,14].

Figure 1: *Effects of oil spills*

2. OIL SPILLS DETECTION USING SATELLITE IMAGES

Oil spills detection using satellite images initially takes input images such as SAR, ERS, ENVISAT satellite data for processing then extract the relevant features and detect oil spills then the data stored into the spill database section, then its statistical analysis and display results geographic through various agencies and governmental organizations.

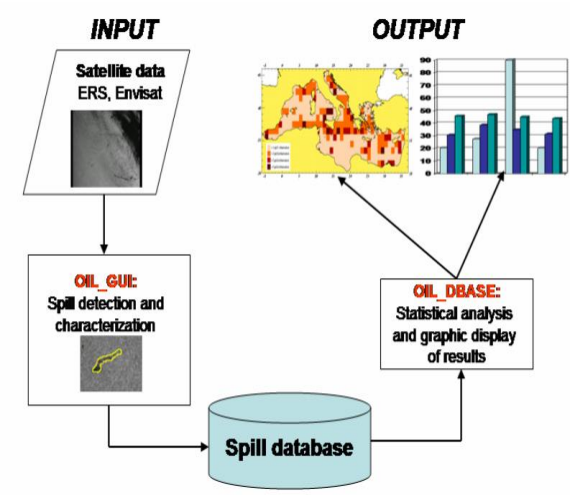

Figure 2: *Oil spills Detection Using Satellite Images*

3. DATABASE

The database is a collection of numerous data, generally stored and can be accessed by the server for oil spills detection. Satellite data collected from various agencies and research organizations to monitor and track disaster. Data are stored in the form of modeling and design techniques. Database storage is very important continues monitoring the natural and man-made disaster. For detection of oil spills different research and methods developed to protect and avoid damages from disasters.

4. ASSESSMENT OF OIL SPILLS

Assessment of oil spills depends on the NRDA (Natural Resource Damage Assessment) process which helps to find out mitigation, type, and amount of work to be established to control the environmental oil spills impacts. NRDA process includes economists, the team of scientists and experts system. It surveys what type of marine and coastal environment were affected based on oil spills, it performs a collection of data to threats assess and injuries to resources naturally, public lost uses and quantify environmental injuries and losses, development plan, flowchart to compensate environment associated losses to public and impacts. It helps in improving the quality of coastal resources and water [13, 14].

Table 1- *Assessment plan for oil spills*

Sl.No	Assessment plan	Responsibilities
1.	Natural Resource Damage Asseeement (NRDA)	Mitigation, type and amount of oil spill assessment.
2.	Oil Spill Risk Assessment (OSRA)	Decision making, design, authorities approval, Stake Holders communication.
3.	Hazard identification/ Environmental issues identification (HAZID/ENVID)	Identification of the possible Causes and consequences of hazardous events.
4.	Hazard and operability analysis (HAZOP)	Systematic approach to identifying hazards and operability problems
5.	Failure modes, effects and criticality (FMECA)	Review of Facility equipment items and effects.

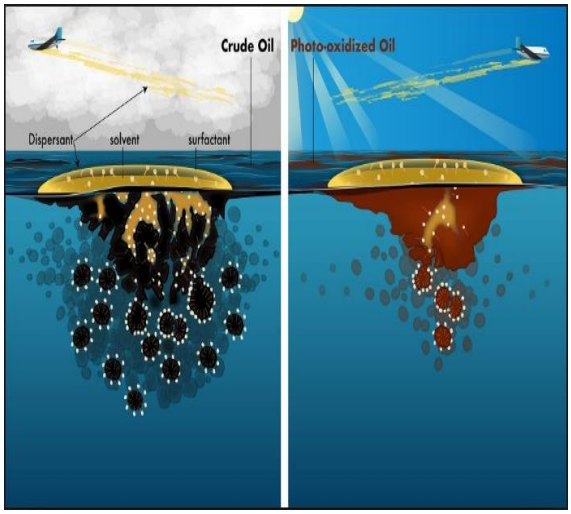

Figure 3. *Oil spills on the Water Surface*

5. RESTORATION OF OIL SPILLS

Restoration of oil spills works on restoring and evaluating responsibility on coastal and habitats damaged due to oil spills disaster. Restoration projects such as creating and restoring wetland habitats, enhancing shorelines and beaches, creating reefs and shellfish habitats, restoring seagrass bed and coral reefs, acquiring, protecting, and restoring waterfowl habitat, removing rivers barriers and allow fish to move and live upstream habitat.

Table 2. *Oil spills Detection General Methodology*

Sl. No	General Methods	Observations
1.	Advisian's Oil Spill Tracking Buoy (OSTB)	Design to track a surface oil spill.
2.	Heavy-duty Design (HD)	Monitor oil spill
3.	Commercial-off-the-shelf(COTS)	Camera based oil spill Monitoring
4.	Digital single-Lens-Reflex (SLR)	Oil spill Monitoring
5.	Field Of View (FOV)	Ocean oil spill
6.	Charge Coupled Device (CCD)	Professional checking and scientific research

OSTB is designed to monitor oil spills from the seafloor in the form of the buoy to check the movement and condition of the oil spills, but it was limited to certain conditions such as sea or interference with 0.5m of column water. Duty Design used to map oil spills and rate dispersion calculation. Commercial (COTS) is a camera-based technology which monitors oil slick over the affected area, it is an optical technique. SLR camera technology capture oil spills images to extract various features for regular monitoring and observations, it helps to increase the surface reflection ratio visible ~400 to ~500nm, but show non-absorption tendencies absorption. FOV is a rotating prism or mirror and direct light to the detector, it works on ocean oil spills monitoring. CCD is more reliable than a mechanical scanner, data collected simultaneously based on tracking directions, it provides good quality images with limited range .

6. FUZZY LOGIC

In center of cluster initially it create guess method, which mark as mean for each cluster locations. The guess done initially in fuzzy logic are likely to be incorrect. Next, it assigns each cluster a membership point during whole process. After assigning membership value iteratively the cluster center will update each cluster data value then it move the center value in right address within the allocated data set. The nearest distance is calculated using Euclidean distance in this work which helps to measure the distance between observations when it includes a continuous variable for the cluster center. In fuzzy c mean the cluster has two center points for attraction. Computed

cluster center helps in differencing the relevant features such as oil spills and look alike. Fuzzy logic assign each data a membership value corresponding to center of cluster based on distance between data point and center of cluster. According to the above steps the cluster center will updated frequently.

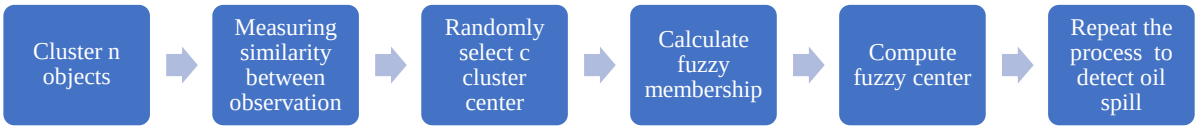

Figure 4. *Fuzzy Logic Algorithm*

It cluster n objects based on attributes into several partitions, where c<n. Initially calculate the distance between the clusters which helps to calculate the similarity between clusters. In fuzzy logic, technique c mean clustering was examined which works on finding the nearest distance called single linkage. Then calculate the similarity between observations using Euclidean distance, which measures the distance between observations. Then update the cluster center by finding the centroid of each cluster through an average of (x-y)axis, the process repeated to find the nearest cluster center by taking the mean of all points in each cluster, repeat the process until minimum values are achieved for oil spills detection.

7. EXPERIMENTAL RESULT

The result display the experimental results of oil spill detection using fizzy clustering techniques. The results extrapolate the oil spills detection output images for the SAR-1 image based on the area of oil spills by monitoring using satellite data. It works on a monitoring model of SAR image which is obtained using a fuzzy algorithm.

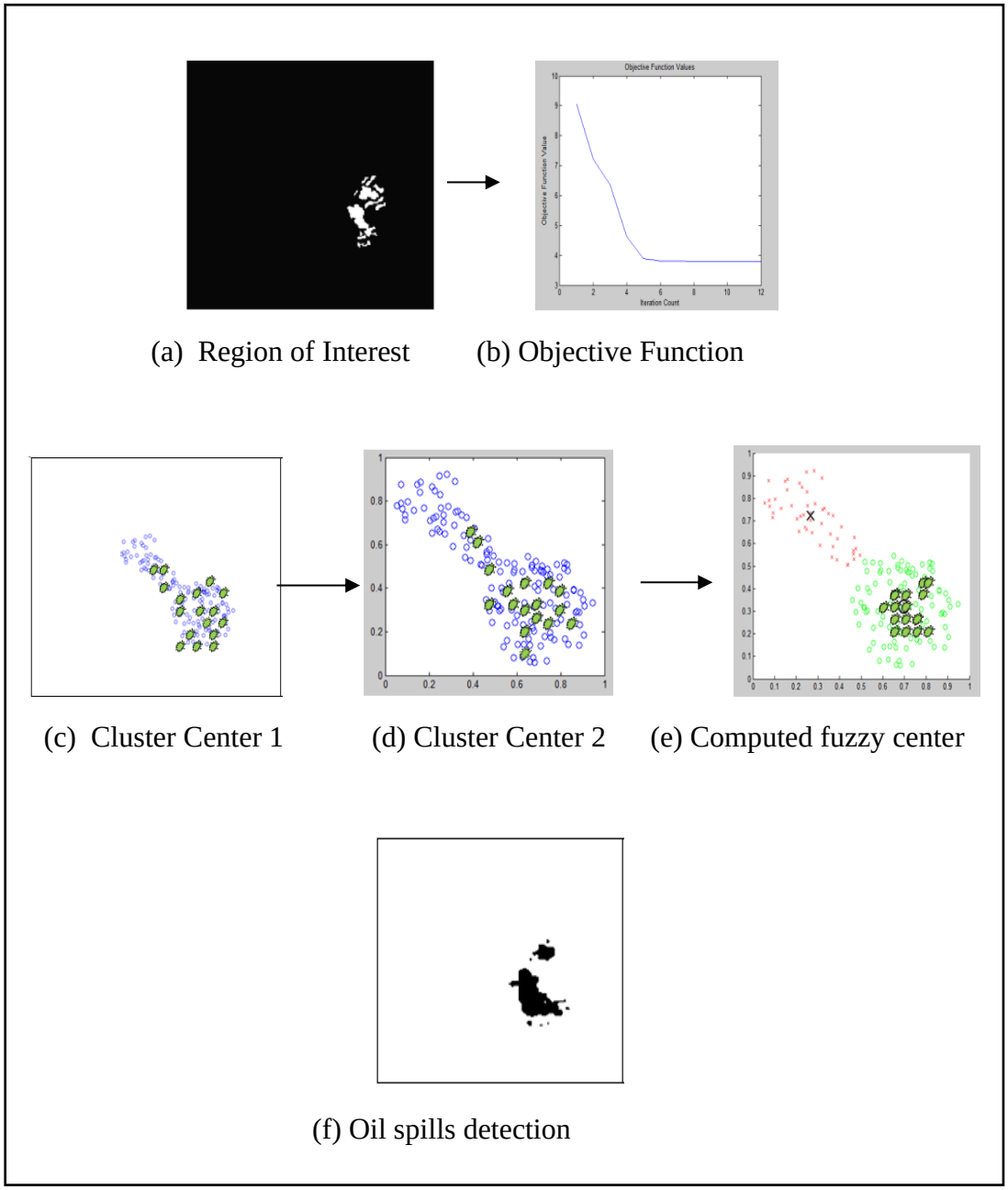

Figure 5: *Results for Fuzzy Logic Algorithm*

The results extrapolate the oil spills tracking output images for the SAR-1 image based on the area of oil spills by monitoring using satellite data. It works on a trajectory model of SAR image which is obtained using a fuzzy algorithm.

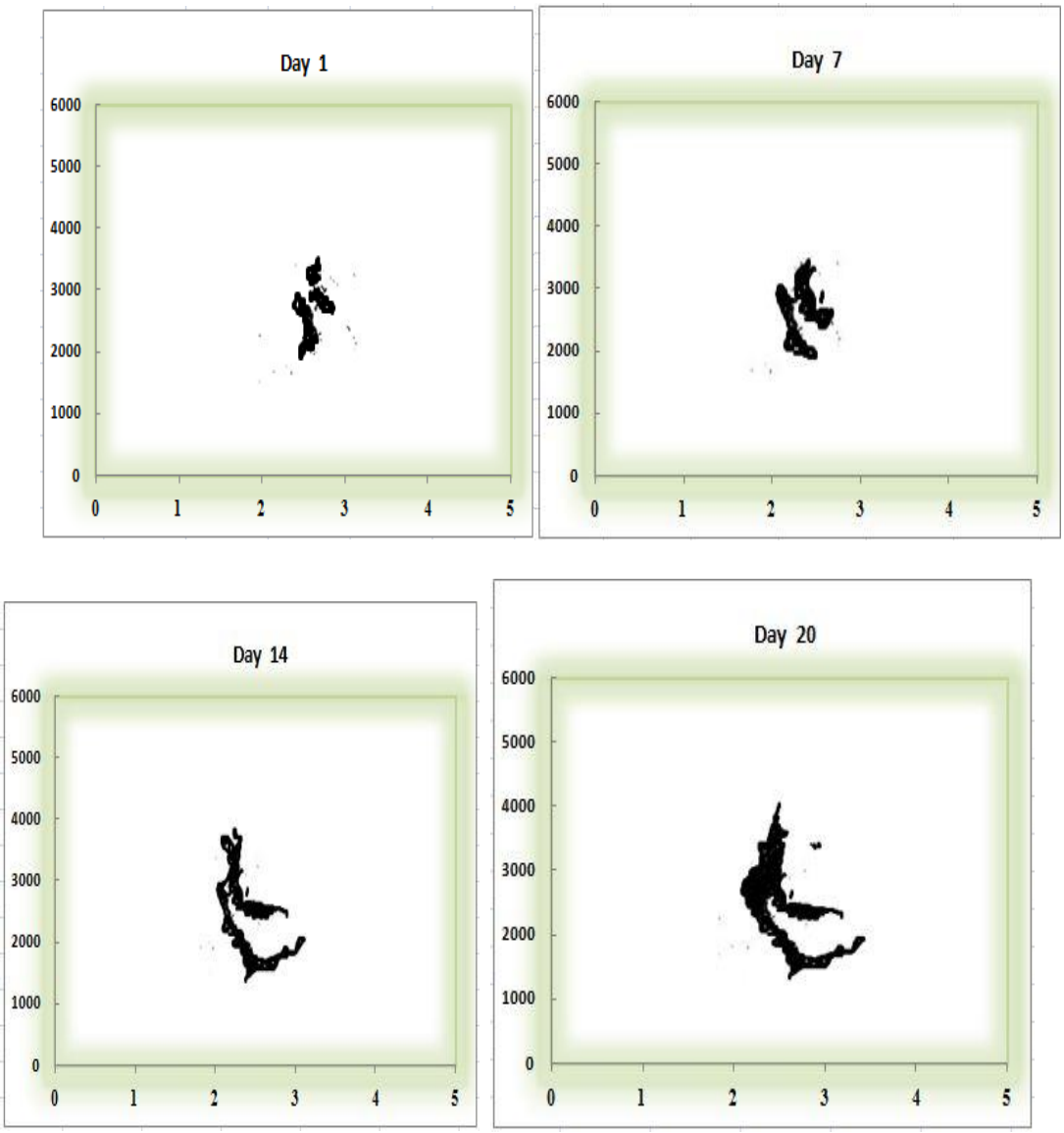

Figure 6: *Oil spills tracking for SAR-1 Days 1,7,14,20 using fuzzy logic*

The figure represents an oil spills tracking model with different days 1, 7, 14, and 20 using a fuzzy logic algorithm. Day 1 image denotes present oil spills resulted in an image with an area of 433.21 km2 , Day 7 denotes resulted in oil spills area with 521.37km2, day 14 denotes with an area of 609.43km2and day 20 represents 923.33km2oil spills with a movement of North-East direction.

CONCLUSION

The researcher investigated and monitors the occurrence of the oil spills in the ocean using image data obtained from the different satellites. In oil spills detection fuzzy logic techniques were used. The study demonstrates that a fuzzy logic technique work as a good monitoring and tracking tool for oil spills detection using satellite images. The researcher also investigates on tracking the spread of oil spills in the ocean using the satellite data of oil spills acquired on successive days or weeks. In the second stage oil spills tracking which helps to work on trajectory modal using SAR images, which was acquired over the same spilled area at different times, duration and days. In oil spills, the tracking technologies used are the fuzzy logic technique. In which result illustrate that fuzzy logic technique can be used as a good tool for tracking and monitoring of oil spills using satellite image.

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