Oil Spill Detection by Satellite Images Using Sequential Detection of Change Test

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Outlines

- Introduction
- Addressed Problem & Some Applications
- Communications System Block Diagram
- Image Pre-Processing
- Sequential Detection of Change Algorithm
- Simulation Results
- Future Work

Introduction

- Oil spills on the sea surface might happen without any previous caution and are seen relatively often. Efficient and effective oil spill monitoring and detection accelerates response time, thus minimizing remediation costs and limiting dangerous impact to the environment.

- An innovative satellite-based oil pollution detecting framework is demonstrated in this presentation, including satellite imaging system modeling, noise model for images transmission and image pre-processing: enhancement and segmentation.

- Finally, an optimized sequential detection of change (SDC) algorithm is proposed to detect oil spills on the ocean surface from the enhanced remote sensing data. Moderate Resolution Imaging Spectroradiometer (MODIS) images of the Gulf of Mexico accident from NASA between May and June 2010 are adopted .

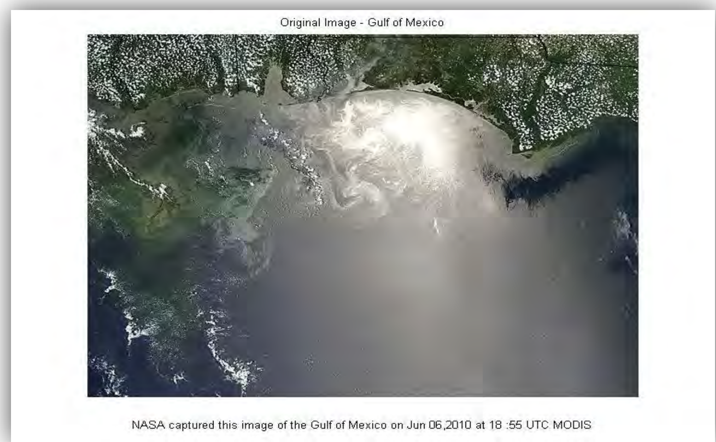
- The results of this research show that the proposed algorithms can effectively distinguish the spills covering vast areas of the marine environment even with severe additive noise and have good separation properties against complex signatures, such as the vicinity to the irregular coast or foggy and cloudy weather conditions.

Addressed Problem

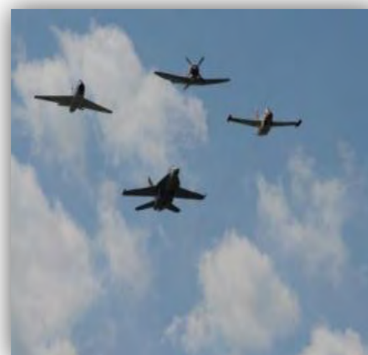
- ***Recognition of Oil Spill shapes in Satellite Images Using the Sequential Detection of Change Algorithm***

Applications

(1) Recognition of Oil Spills

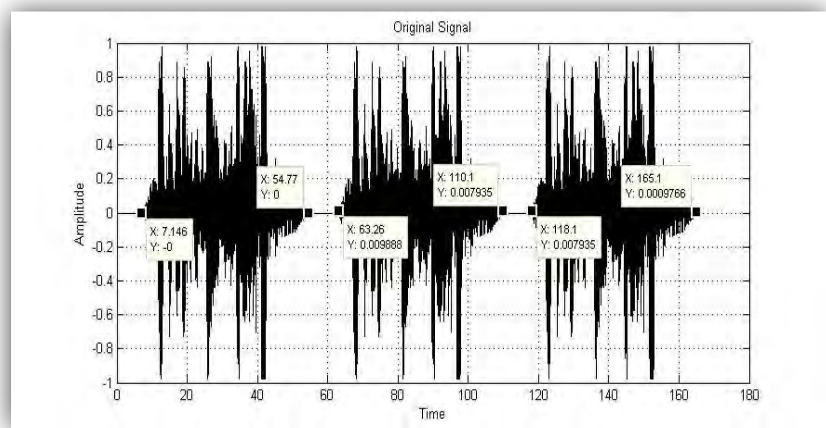


(3) Recognition of Airplanes

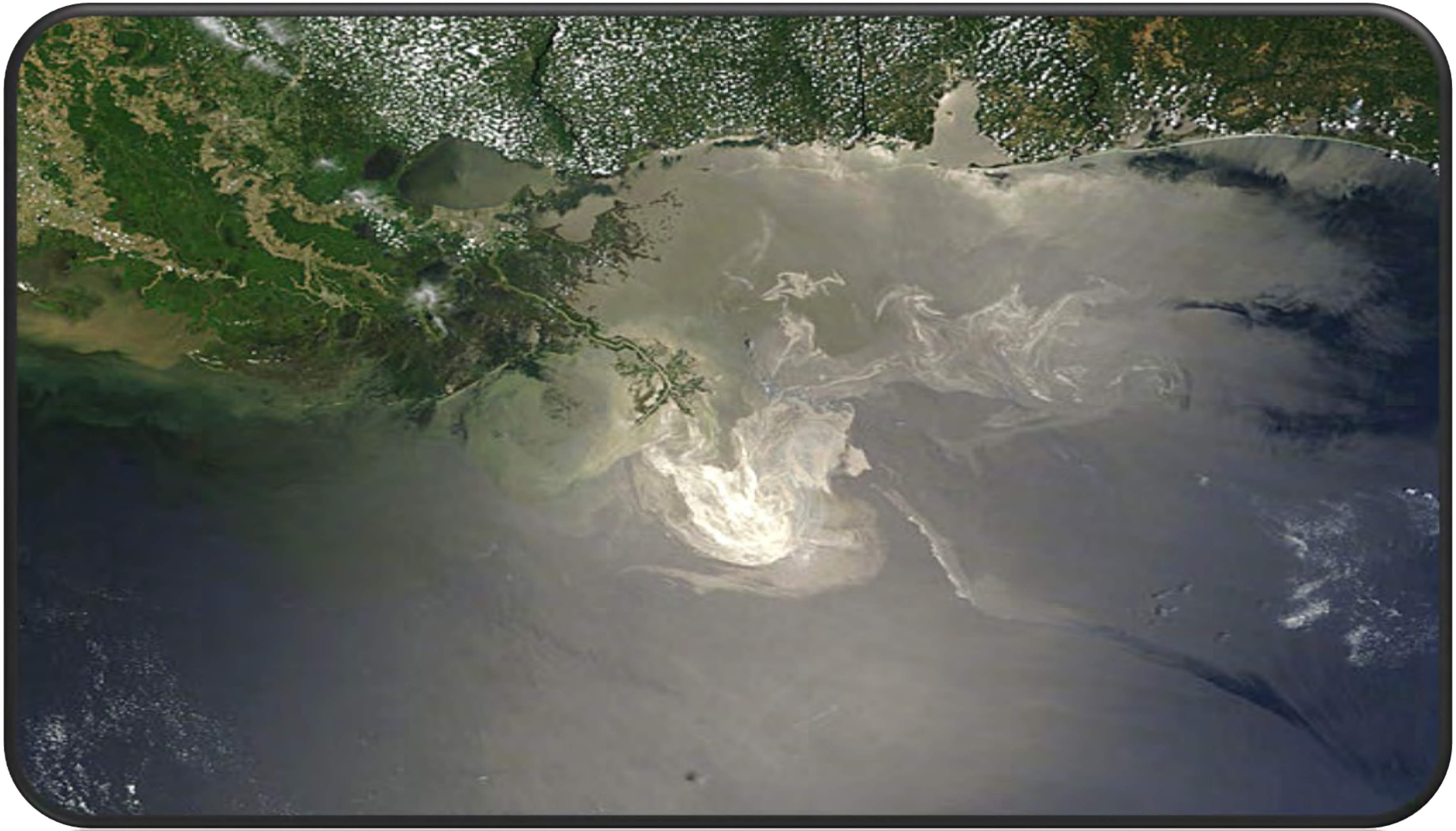


(2) NEOs Detection

(4) Voice Activity detection and Recognition of Cyber Exploits

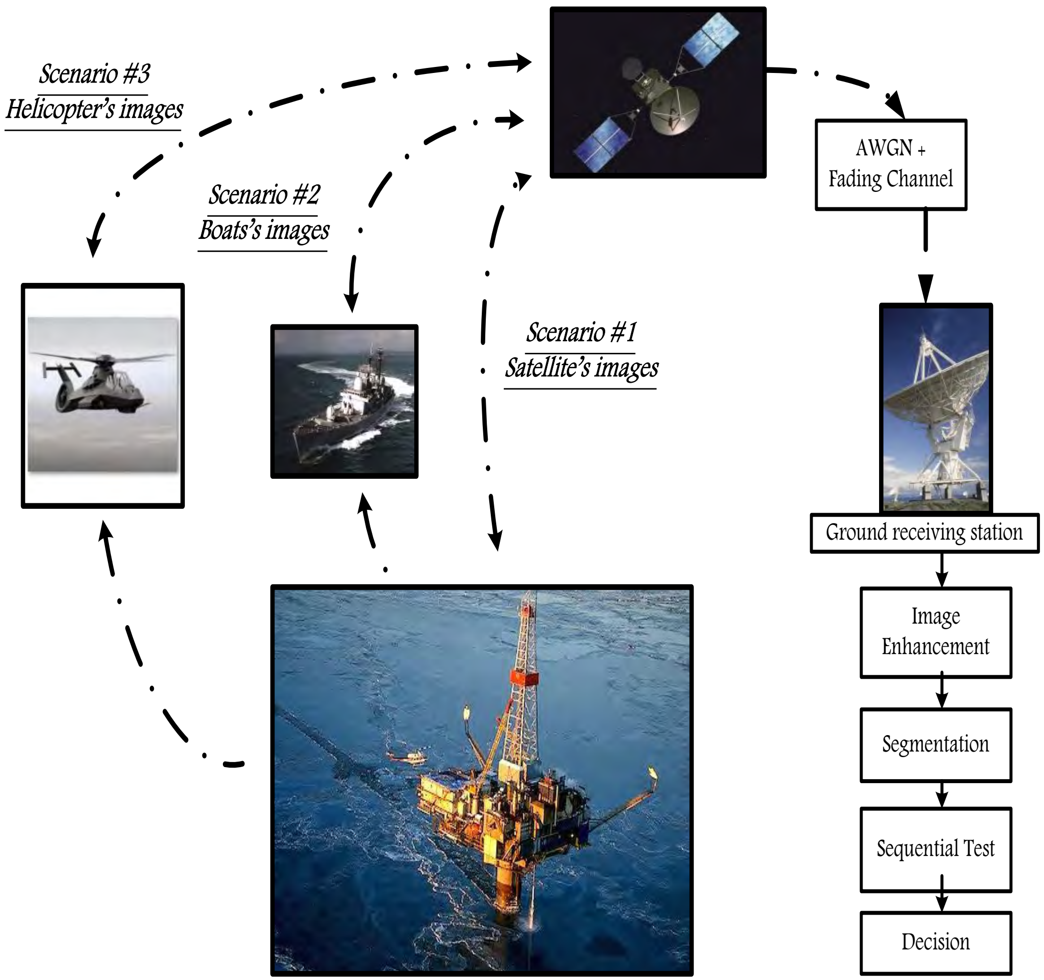


Area of Study (NASA Satellite Images)



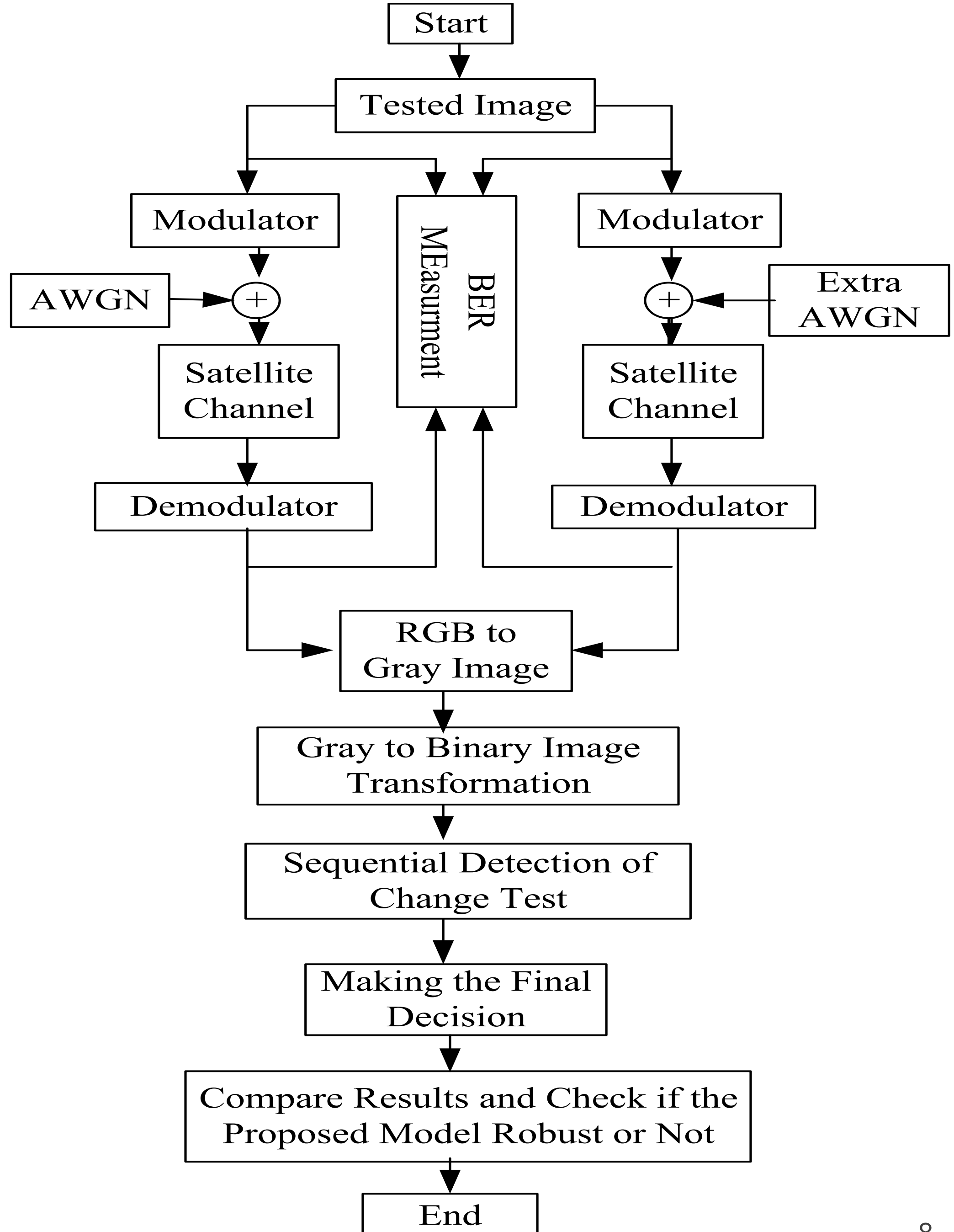
How the System Operates

- ***Scenario #1:*** Tracking and monitoring directly from the satellite.
- ***Scenario #2:*** The boat takes multi-images from the interested area around the boat and sends them from LAN (Local Area Network) to WAN (Wide Area Network such as VSAT). Then, from boat's VSAT to the ground receive station to process them and detect if there is any oil spill.
- ***Scenario #3:*** The helicopter takes multi-images from the region of interest and sends them to the ground receiving station to process them and detect if there is any oil spill.



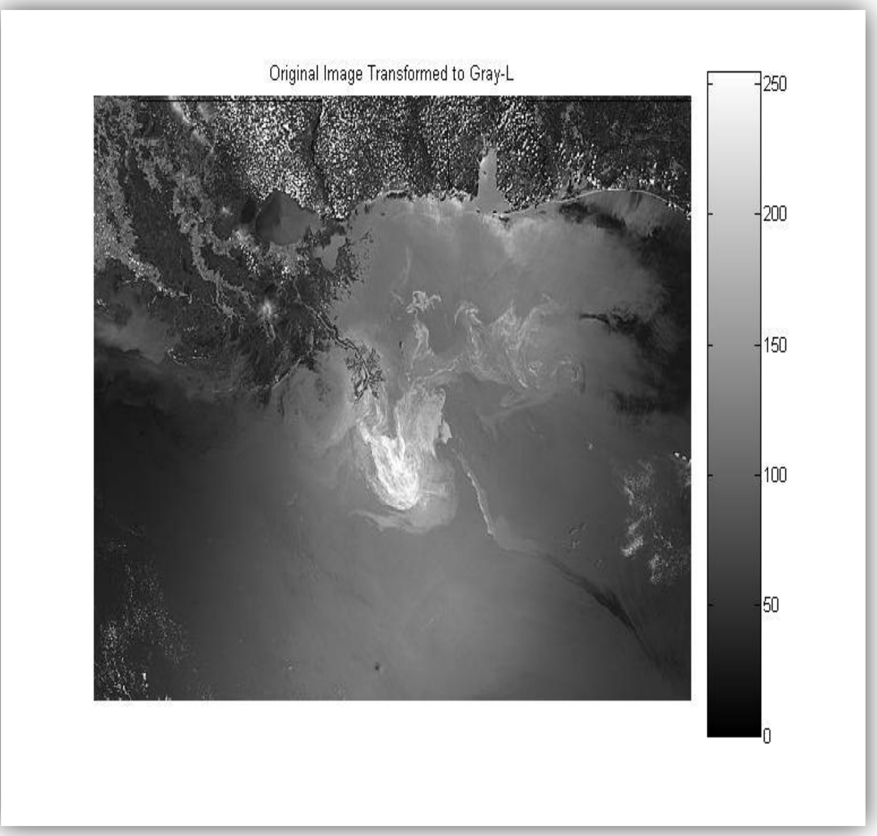
Approach

1) Modeling the Image.
2) Add AWGN to the image.
3) Convert the RGB image to Gray image then to Binary Image using some threshold.
4) Assumption: each pixel is independent with the neighbors pixels around.
5) Use Bernoulli distribution.
6) Compute the p, q, and the updating step.
7) Start applying the sequential detection of change test.
8) Make the final decision.

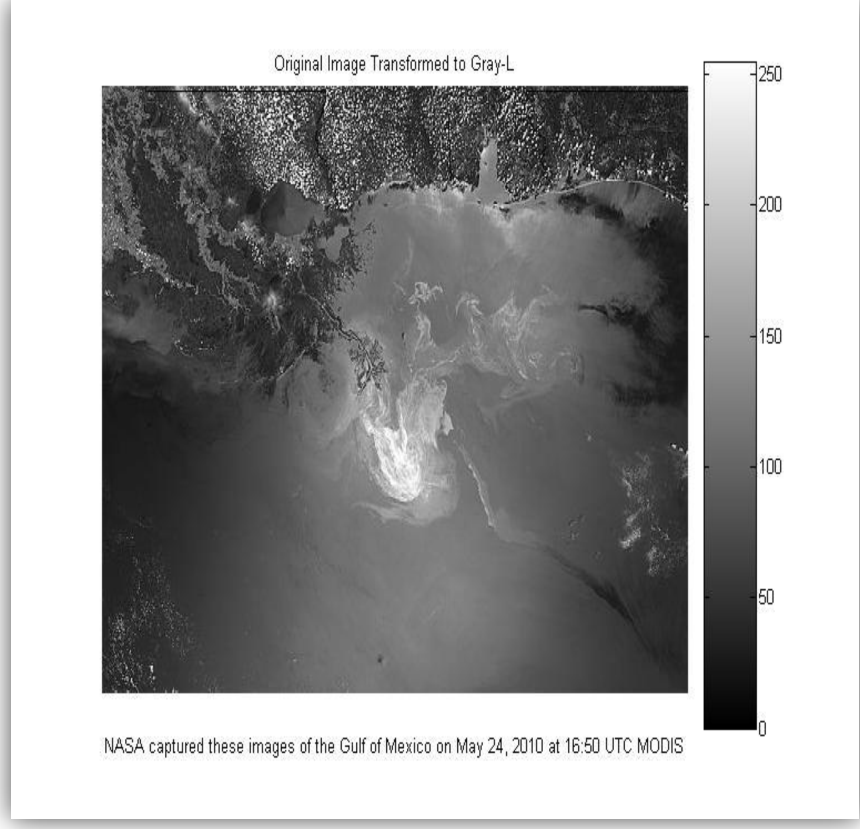


Convert RGB image to Gray-Level

RGB TO GRAY-LEVEL IMAGE

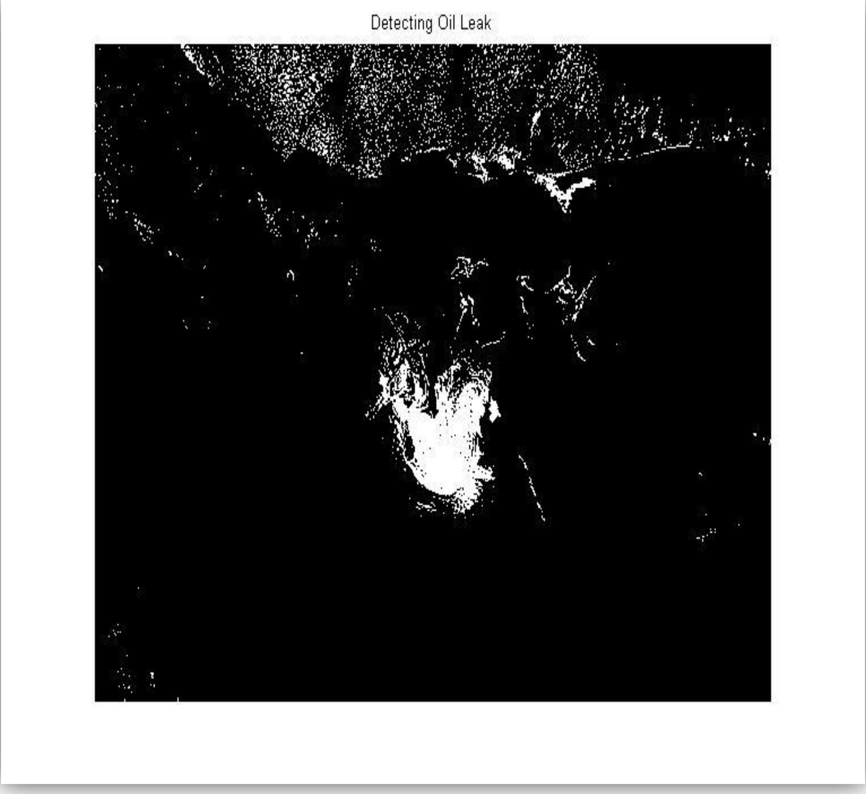


RGB TO GRAY-LEVEL IMAGE WITH MORE AWGN

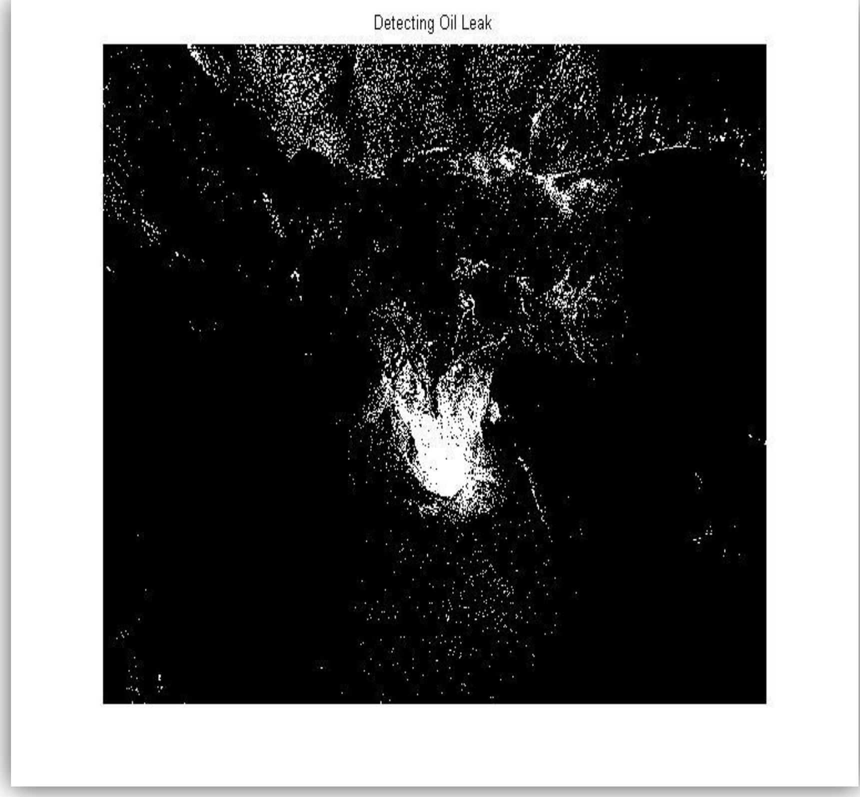


Convert Gray Image to Binary Image

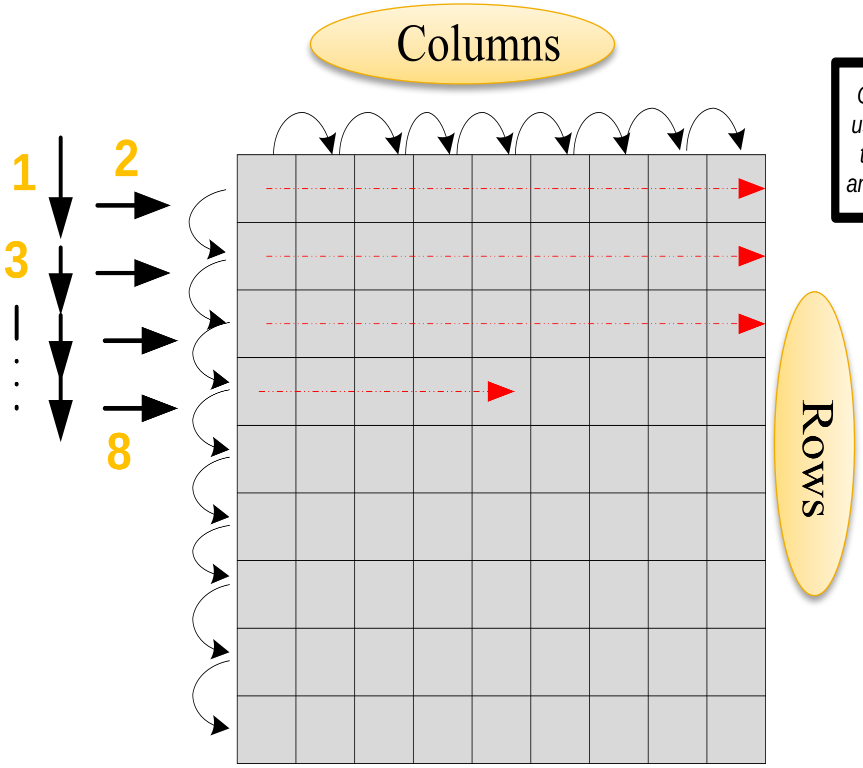
GRAY IMAGE TO BINARY

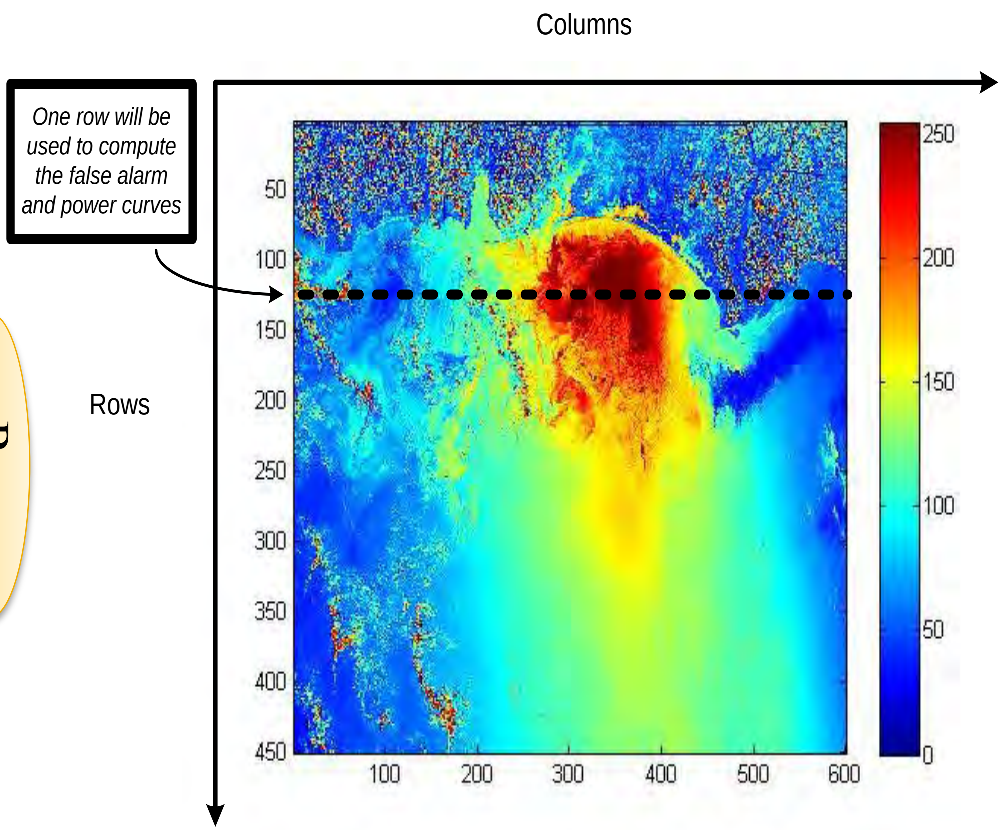


GRAY IMAGE TO BINARY WITH MORE AWGN



Scanning Images





Detection of Change Algorithm

(a) Have (m-1) parallel algorithms operating. The i^th^ algorithm; $\{i=1, \ldots, (m-1)\}$ is monitoring a $\{f_0 \rightarrow f_i\}$ shift. $T_n^{0i}(x_1^n)$ denotes the operating value of the i^{th} algorithm at time n, given the observation sequence . The operating value is updated as follows.

$$T_0^{0i} \equiv 0$$

$$T_n^{0i}(x_1^n) = \max\left(0, T_{n-1}^{0i}(x_1^{n-1}) + \log \frac{f_i(x_n \mid x_1^{n-1})}{f_0(x_n \mid x_1^{n-1})}\right)$$

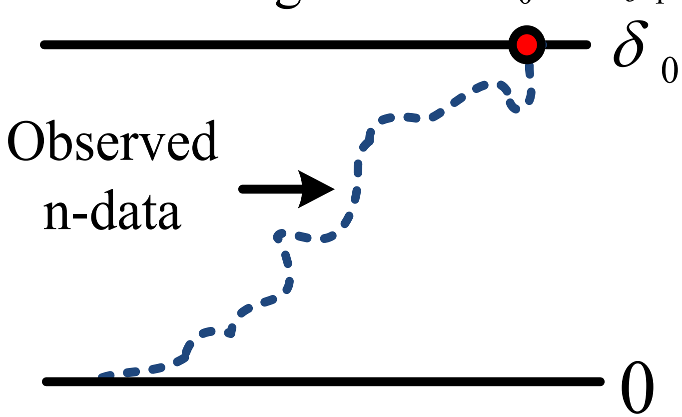
(b) Select a threshold $\delta_0 > 0$.

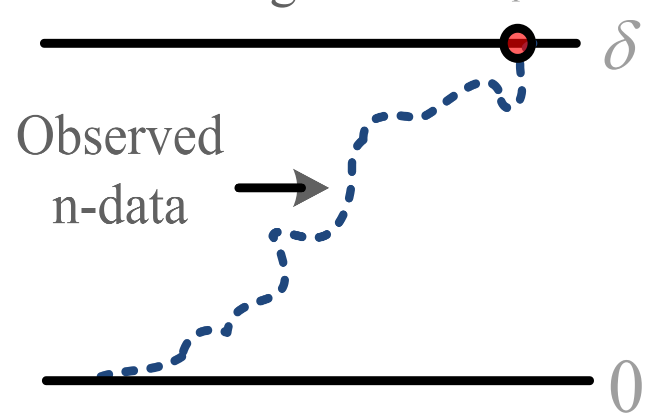
(c) The algorithmic system stops the first time n when either one of the (m-1) parallel algorithms crosses the common threshold δ_0 .

(d) If the i^{th} algorithm is the one that first crosses the threshold, then it is declared that a $\{f_0 \rightarrow f_i\}$ shift has occurred.

Reinitialization Scenario: Detection of Change Algorithm for the Bernoulli Model

For $f_0 \rightarrow f_1$	For $f_1 \rightarrow f_0$
Select δ_0 positive threshold. Then,	Select δ1 positive threshold. Then,
$T_0 \equiv 0$ $T_n(x_1^n) = \max\left(0, T_{n-1}(x_1^{n-1}) + x_n + \gamma(q,p)\right)$	$T_0 \equiv 0$ $T_n(x_1^n) = \max\left(0, T_{n-1}(x_1^{n-1}) - x_n - \gamma(q,p)\right)$
Stop the first time n such that $T_n(x_1^n) \geq \delta_0 > 0$	Where $\gamma(q,p) = \dfrac{\log[(1-q)/(1-p)]}{\log[q(1-p)/p(1-q)]}$
Decide change from $f_0 \rightarrow f_1$	Decide change from $f_1 \rightarrow f_0$





p and q Optimization

$$\log \frac{f_1(x_i)}{f_0(x_i)} = \log \frac{p^{x_i}(1-p)^{1-x_i}}{q^{x_i}(1-q)^{1-x_i}}$$

To compute both p and q, we need to train our system using many different images. In this way, the range of each p and q can be estimated and saved in our data base as shown below:

1) Select many different images.

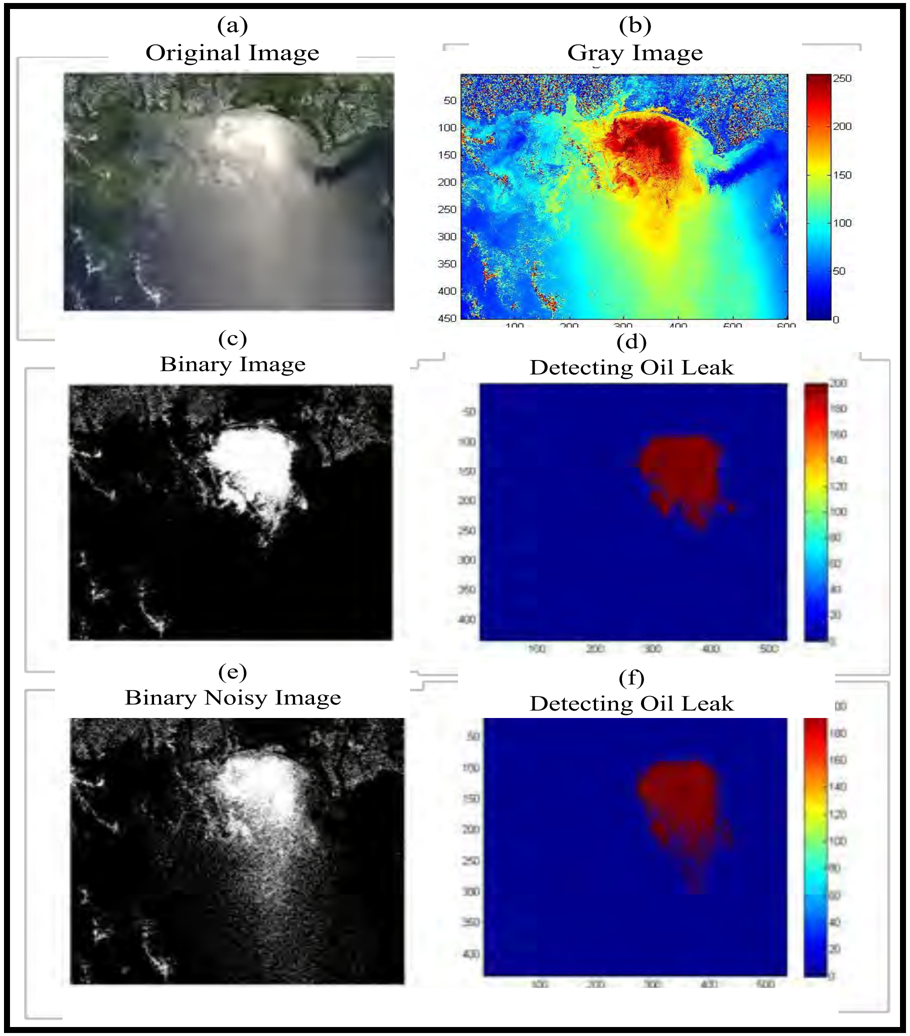
2) Compute p by counting the number of oil spill pixels divided by the number of background pixels.

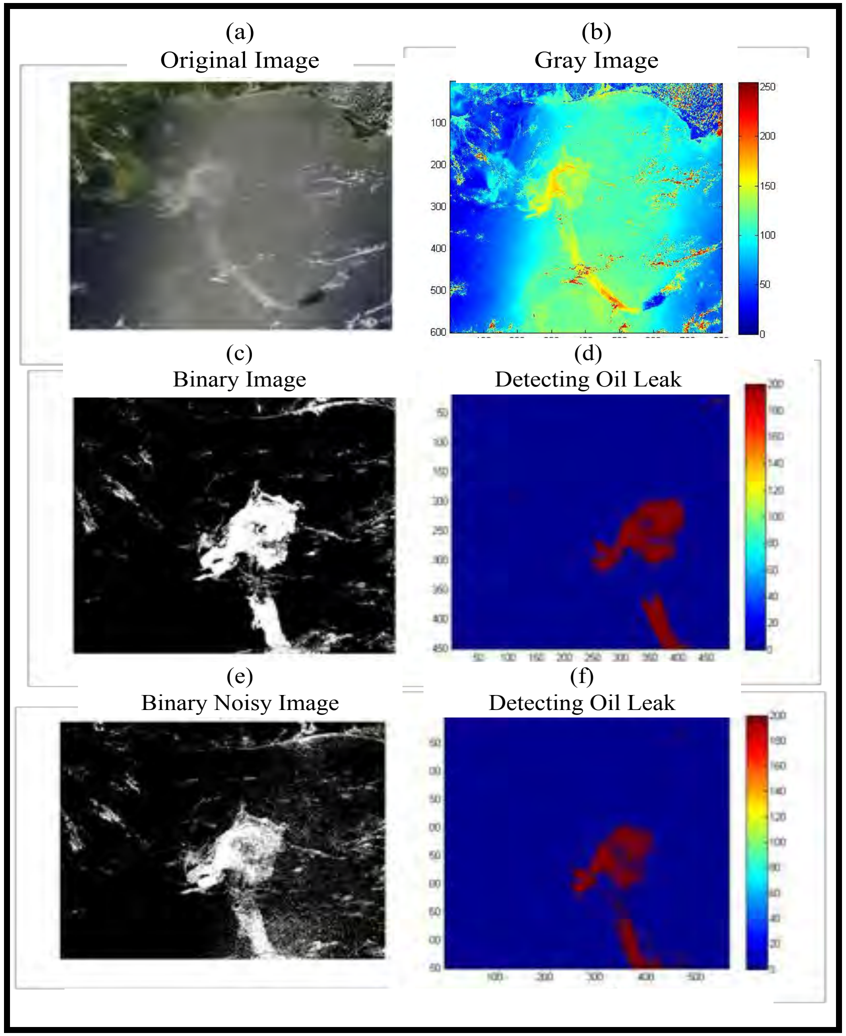
3) Then, compute q using this formula =>

$$q = \frac{\textit{Number of affects that look like oil}}{\textit{Total number of pixels} - \textit{Number of oil spill pixels}}$$

4) Results: after repeating the same procedure on many images, it has been found that the range of q is approximately (0.2 to 0.4) while p is between (0.045 to 0.08).

Final Oil Spill Detection Results

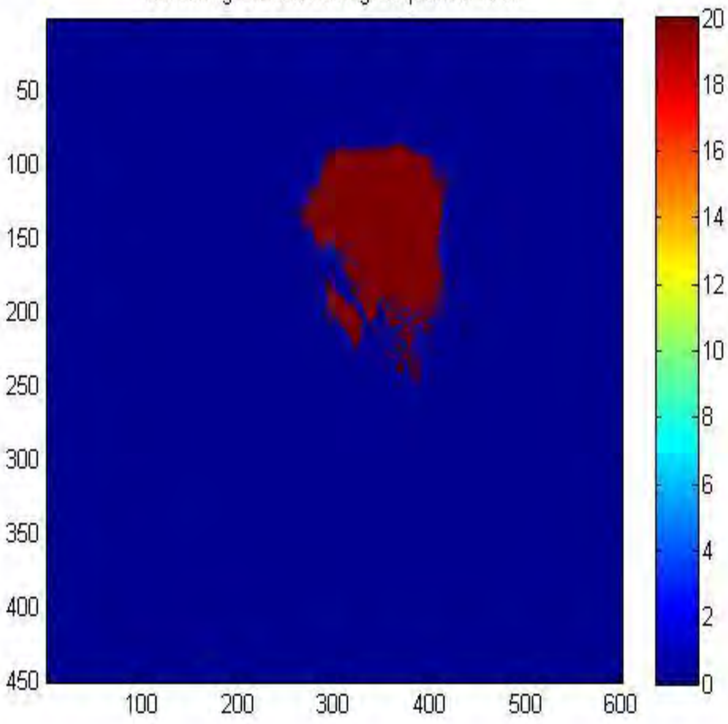




Results: Recognition of Oil Spills

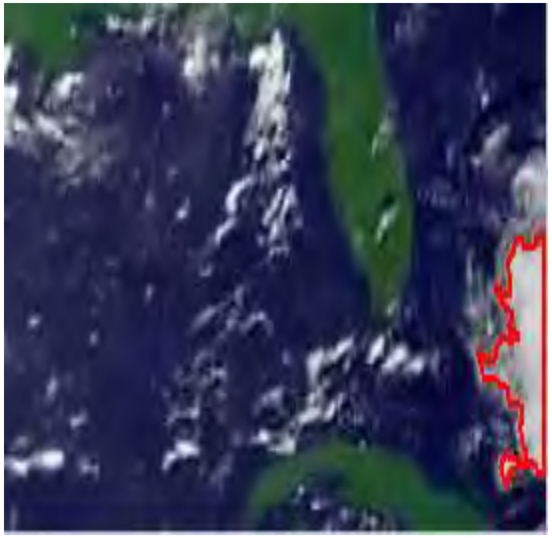
Recognition of Shapes of Interest in Images

NASA captured this image of the Gulf of Mexico on Jun 06,2010 at 18 :55 UTC MODIS



Future Algorithmic Extensions-Modifications

- Started introducing higher level models instead of the Bernoulli model.
- Started working on real time videos using the sequential detection of change algorithm.
- Some Results: 1) Oil Spill Detection; 2) Airplanes Detection; 3) Hurricanes Detection; 4) NEOs Detection; 5) Submarine Detection,….etc



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Thank you

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