Unique Methodology to Detect and Dispose Oil Spill from Sea Water

Reena Rosilin Raj.I [1], S.Abirami[2], S.K.Deepikaa[3],L.Priya[4]
[1] *Assistant Professor, Department of ECE, DMI College of Engineering, Tamilnadu 600123*
[2,3,4]*UG Students, Department of ECE, DMI College of Engineering, Tamilnadu 600123*

***Abstract* - The Sea is often a fragile environment to be protected against possible pollutants. In this context, the present work contributes to its safeguard by proposing a new buoy equipped with advanced sensors for the detection of oil spills. In particular, the buoy is provided with various sensors for the evaluation of both meteorological and marine parameters (e.g., waves, wind, temperature), and chemical/physical data acquired by an electronic nose system specifically designed for the detection of hydrocarbons. The electronic nose is composed of a flow chamber, a chamber equipped with photo ionization sensors, pumps and valves for air inlet and outlet, and a low-cost electronic board. The designed system samples the air above the water and produces data that are processed through two artificial neural networks allowing for a classification of detected hydrocarbons and overall pollution level. Suitable network interfaces and a connector toward a Marine Information System (MIS). spill location is obtained using GPS. Spill location are transmitted to a remote PC on the nearest offshore platform using an IOT wireless connection.**

***Index Terms* - Crude Oil Spill, Oil Spill Detection, marine pollution, remote sensors, microwave sensors.**

INTRODUCTION

Hundreds of crude oil spill incidents occur every year in oil producing countries and result in devastating national consequences to the environment, society, health, and economy [1]-[5]. If oil companies and governments are able to detect spills as soon as they occur, and take immediate action, there would be minimal damage to the environment and the financial losses associated with spills would be drastically reduced. Several methods have been employed for spill detection. In the Niger Delta of Nigeria, pipeline pressure monitoring and human surveillance units are used for spill detection. However, pressure monitoring does not always detect spills promptly and the location of a spill (proximity to communities, water or swamp spills) affects the speed of detection by human surveillance [6]. Remote sensing is the predominant method currently used for oil spill detection. Remote sensing involves the use of sensors, such as visible light sensors, infrared sensors, microwave sensors, radar sensors, and laser fluorosensors, aboard an airborne or Unmanned Aerial Vehicle (UAV) platform or a satellite-based platform to provide surveillance for crude oil spills over geographical regions [7]–[9]. Crude oil spills from subsea crude oil pipelines are particularly difficult to detect early because of inaccessible nature of their location. Pipeline pressure monitoring does not detect spills promptly, human surveillance of the right of way is impossible as these pipes are typically located 1,000- 2,000 m below sea level. For instance, the 2016 spill from Royal Dutch Shell’s offshore Brutus platform that released 2,100 barrels (123,900 liters) of crude oil from a pipeline 840 m below sea level [10]. In 2016, it took SPDC days to discover a spill due to sabotage from the 4.7 km (48-inch diameter) Forcados Crude Oil Export underwater pipeline, located in water depth of six meters in Nigeria. Diving teams had to be employed to detect the source of the leak [10]. While satellite remote sensing is predominantly used for monitoring offshore crude oil spills and their movement directions as well as the discharged oil quantities, they are not able to detect oil spills immediately due to temporal resolution, weather conditions, lack of early high spatial resolution information, as well as time taken to acquire and process the images to detect the spill [11].

Oil spills can result in serious environmental pollution affecting communities found on the shorelines. The effects of an oil spill directly hit the marine animals and plants, which live in the path of the oil spill. An immediate response is necessary as marine, and many aquatic species are directly affected by the pollution.

A possible ecological imbalance may occur as oil spill continually spread as it will directly hit not only marine species but also fishermen around the area of the spread. A possible decrease in the fish production and decrease in marine life quality is also expected. Therefore, to address this issue a real time transmission and detection device shall be developed to model the presence of oil spill thru artificial illumination. The modelling of the light intensity thru artificial illumination will give the government an idea of how quick their response shall be. The study aims to provide solutions to present problems and needs, to suffice or provide basic and extensive knowledge regarding oil spill, to improve disaster response, to enrich research methods for the oil spill, and to somehow support government thrusts.

The primary objective of this paper is to design and develop an oil spill detection and transmission system using artificial illumination with LEDs. First, is to design a sensor that can detect an oil spill thru LEDs and Phototransistors. The second objective is to design a buoy that will be used to carry the oil spill detector. Third, to have a renewable power supply ready battery (solar power) that will maintain the power of the detector, which is to transmit the data via SMS and telemetry technology and last, to evaluate the results. This study is a significant endeavour and contribution in solving problems about increasing problem to disaster management in an ocean setting. This study is beneficial to the government and people as they are able to determine in real-time the spread of the oil spill. By understanding the direct effect of the oil spill, it bridges knowledge gaps to improve the government and private sector response in cleaning this marine pollution.

RELATED WORK

Remote oil sensing

Remote sensors work by detecting sea surface properties such as colour, reflectance, temperature and roughness (SEOS, Introduction 2008). There are two types of sensors: active and passive. Active sensors send out electromagnetic waves in order to track pollutants in the sea. The signal is changed on the water surface and the reflected signal is detected by the sensor. Advantages of the active sensors include the ability to obtain measurements anytime, regardless of the time of the day or season (Natural Resources Canada, 2015), while this is not the case for almost all passive sensors. Passive sensors measure radiation that has been emitted or reflected from the sea surface or the pollutant respectively and their application consequently requires daylight clear skies and is therefore very limited (SEOS, Introduction 2008).

This article reviews the most commonly used remote sensors for detection of oil spills like laser fluorosensors, optical remote sensing and microwave sensors, which are the most commonly used sensors for oil spill remote sensing (Topouzelis 2008; Fingas, Brown 2014).

Microwave sensors

As it has been mentioned before, microwave sensors are becoming the most commonly used sensors for oil spill remote sensing, particularly the active sensors such as radars (Fingas, Brown 2014). However, there are also passive microwave sensors.

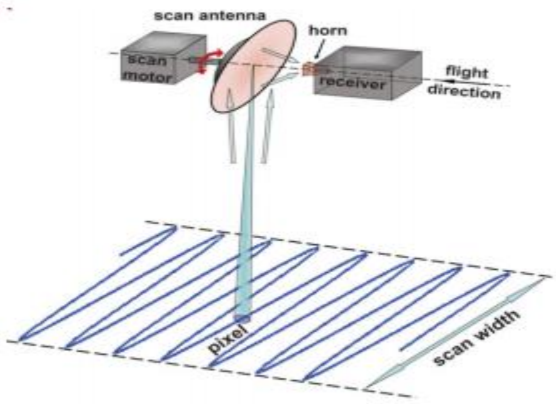

Fig. 1. Microwave radiometer scanning operationble to penetrate cloud cover, fog, haze or rain and their application consequently requires daylight clear skies and is therefore very limited (SEOS, Introduction 2008). However, the exception could be the passive microwave radiometers (MWR). They detect the presence of an oil film on water by measuring the reflection (electromagnetic energy) of the surface as excited by the radiation from space (Fingas, Brown 2014; Philipson, Philpot 2012). This passive sensor detects radiation emitted or reflected by an object in the microwave range at frequencies of about 1 to 100 GHz. Microwave radiometers are generally designed as scanning instruments (Fig. 2) that allow taking images from the ground (SEOS, Supplement 2.17 2008). The best-known active microwave sensor is Synthetic Aperture Radar (SAR) (Fig. 3) which captures two dimensional images (Topouzelis 2008). The image brightness is a reflection of the microwave

backscattering properties of the surface (Brekke, Solberg 2005). Basically, SAR can detect oil slicks over the ocean surface due to the oil capability to reduce the friction velocity, responsible for the energy exchanges between sea surface wind and ocean waves, and to dampen the short gravity and capillary waves, i. e., the Bragg resonant centimetric waves responsible for the backscattering signal measured at the SAR antenna (Buono et al. 2015). SAR with relatively wide coverage and day/night/all-weather imaging capabilities has been widely used to provide valuable synoptic information about the position and size of oil spills and seeps (Xu et al. 2013).

Laser fluorosensors

Laser fluorosensors are active sensors and that means they provide their own source of excitation. Therefore, the laser fluorosensors can operate as well during full daylight conditions as it does at night (Brown, Fingas 2003). Laser fluorosensors are useful instruments because of their unique capability to identify oil on backgrounds that include water, soil, weeds, ice and snow. They are the only sensors that can positively discriminate oil on most backgrounds (Fingas, Brown 2014). Laser fluorosensors make use of the phenomenon that aromatic compounds in petroleum oils absorb ultraviolet light and become electronically excited. This excitation is rapidly removed through the process of fluorescence emission, primarily in the visible region of the spectrum (Fingas, Brown, 2014). Laser fluorosensors can be operated aboard an aircraft to analyse physical and biological parameters of waters such as the turbidity and the algae content, or to detect marine pollutants as shown in Figure 5 (SEOS, Supplement 2.19 2008).

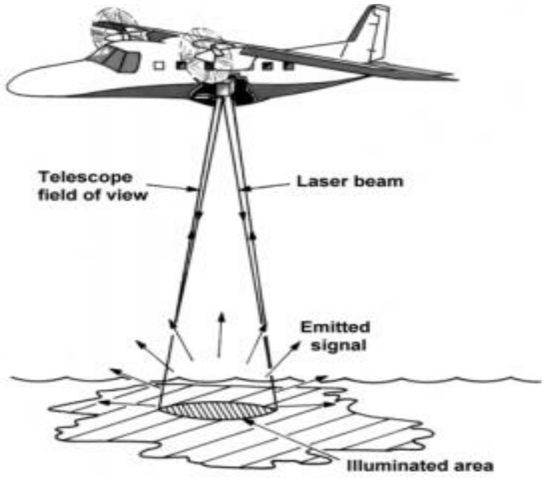

Fig. 2. Measuring principle of the laser fluorosensor

A laser fluorosensor allows to detect very thin oil films in the thickness range of about 0.1 to 10 µm. Different oil types have distinct fluorescence spectra with light oils fluorescing in the blue and heavy oils fluorescing towards the green (Leifer et al. 2012). It is also possible to determine the film thickness, provided the oil absorbance is known, and to classify the oil type (the absorbance of the oil is estimated from the oil type for calculating the oil film thickness). Therefore, the laser fluorosensor is primarily used for analysing deliberate discharges of oil into the sea. The thickness of large oil volumes, as they occur after accidental discharges, cannot be measured. A laser fluorosensor can only be operated in good visibility conditions. As an active sensor it does not depend on daylight and can also be used at night (SEOS, Supplement 2.19 2008). Laser fluorosensors have a significant potential as they may be the only means to discriminate between oiled and unoiled seaweeds and to detect oil on different types of shorelines.

METHODOLOGY

The buoy support and casing of the sensors and modules were designed so that they can withstand the water element and waves. Moreover, the fiberglass casing was ensured to be sufficient enough to support and protect the modules. The design of the circuits in PCBs needed in the prototype were planned to be fit enough in meeting the objectives of the research. The LED, Phototransistor, GSM and battery circuits were made and connected in such a way that the prototype will suit the desired oil spill detection and transmission. The buoy support and casing of the sensors and modules were designed so that they can withstand the water element and waves. Moreover, the fiberglass casing was ensured to be sufficient enough to support and protect the modules. The design of the circuits in PCBs needed in the prototype were planned to be fit enough in meeting the objectives of the research. The LED, Phototransistor, GSM and battery circuits were made and connected in such a way that the prototype will suit the desired oil spill detection and transmission.

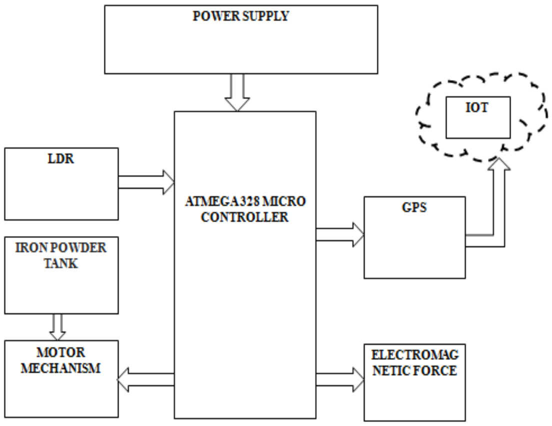

Fig 3: Block Diagram

Hardware Requirements

- Power Supply
- Iot
- Micro Controller
- Electromagnetic Force
- Ldr
- Iron Power Tank
- Motor Mechanism
- Gps

Software Requirement

- ARDUINO IDE
- Embedded C

HARDWARE IMPLEMENTATION

Arduino UNO

The Arduino UNO is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by arduino. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 Digital pins, 6 Analog pins, and programmable with the Arduino IDE (Integrated Development Environment) via a type B USB cable. It can be powered by a USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts. It is also similar to the Arduino Nano and Leonardo. The hardware reference design is distributed under Common Creative Attribution Share-Alike 2.5 license and is available on the arduino website. Layout and production files for some versions of the hardware are also available. "UNO" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The UNO board and version 1.0 of arduino Software (IDE) were the reference versions of arduino, now evolved to newer releases. The UNO board is the first in a series of USB arduino boards, and the reference model for the arduino platform. The ATmega328P on the arduino UNO comes preprogrammed with a boot loader that allows uploading new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol. The UNO also differs from all preceding boards in that it does not use the FTDI USB-to serial driver chip. Instead, it uses the Atmega16U (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

Fig -4: Arduino Board

LCD

Liquid Crystal Display (LCD) is used to display the output to the user in the form of GUI (Graphic User Interface) and a mono chromatic display. LCD used in this project is JHD162A series. There are 16 pins in all. They are numbered from left to right 1 to 16 (if you are reading from the backside). Generating custom charcters on LCD is not very hard. It requires the knowledge about custom generated random-access memory (CG-RAM) of LCD and the LCD chip controller. Most LCDs contain Hitachi HD4478 controller. CG-RAM is the main component in making custom characters. It stores the custom characters once declared in the code. CG-RAM size is 64 byte providing the option of creating eight characters at a time. Each character is eight byte in size.

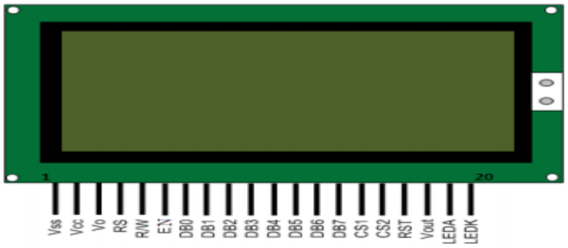

Fig 5: LCD

LDR Sensor

Photo resistors, also known as light dependent resistors (LDR), are light sensitive devices most often used to indicate the presence or absence of light, or to measure the light intensity. In the dark, their resistance is very high, sometimes up to 1MΩ, but when the LDR sensor is exposed to light, the resistance drops dramatically, even down to a few ohms, depending on the light intensity. LDRs have a sensitivity that varies with the wavelength of the light applied and are nonlinear devices. They are used in many applications but are sometimes made obsolete by other devices such as photodiodes and phototransistors. Some countries have banned LDRs made of lead or cadmium over environmental safety concerns.

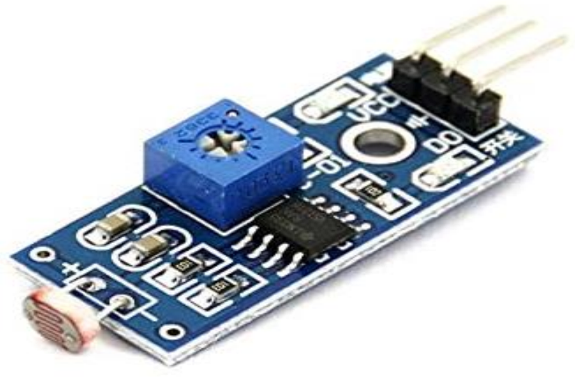

Fig 6.LDR sensor

Oil Spill Detection

The first stage is detecting oil spills on various kinds of surfaces using a sensor that can provide the necessary information required to model the spread of an oil spill. Oil spill sensor will be used to monitor and determine the presence of an oil spill. For detecting oil spill, there has been different sensor available. Visible sensor, Infrared sensor, Ultraviolet sensor, Synthetic Aperture Radar (SAR), Microwave, Laser flouro sensor and Laseracoustic oil thickness sensor. The Oil Spill detector/ sensor will be composed of an LEDs and Phototransistor sensor. The phototransistor sensor will then be interfaced to the microcontroller and will send the captured imaged thru telemetry. The image acquired will be compared with the previous study result for calibration. The results will determine the presence of oil spill and will alert authorities by sending them an SMS. The sensor stand needs to be designed in the form of the monitoring buoy that will house all the devices.

Calibration Process

The second stage is the dish-shaped floater. It was designed as a sensor platform for operational detection on the sea surface, the oil can enter the optical detection part of sensor through two holes on the water line side of the floater. The phototransistor sensor device determined the amount of light which was calibrated with the corresponding light intensity. The calibration will be done using a light intensity meter (lux meter). The measurements were analyzed and scaled for the light intensity and voltage output to be calibrated. Sample oil thickness was also calibrated for the voltage output. Then, the data was transmitted using a telemetry technology (IOT). It was done by using a microcontroller that is responsible in acquiring the data. The AceDuino microcontroller was programmed and calibrated for the ranges of the output voltage from the phototransistor, and the values from the flux meter and the corresponding oil thickness range. The program was also configured to send oil detection status changes from every 4 seconds to the IOT module

Telemetry

And the last stage is the transmission system which is received from the data acquired from the floating buoy using telemetry. The oil spill detection, oil thickness, and light intensity data will be transmitted via GSM. The power supply will be provided by the charged batteries (solar panel ready) with optional solar energy. The telemetry system will be composed of an adapter coupled to the device. The receiver will have the analyzing capability thru a develop algorithm to show the pixel intensity for a given thickness and frequency. Then, this will alert the authorities sending SMS about the details about an oil spill.

RESULTS AND DISCUSSION

To analyze the data above all the units are converted. The time of charging has an original unit of minutes converted to seconds. The water depth in feet is converted in terms of meters, and the average wind speed is in km/hr is converted to m/s. The units are to be converted because the formula in obtaining the power is in meters and seconds. To predict the Pixel

Intensity in terms of lumens, a mathematical modeling was formulated as the water depth, oil spill thickness and wavelength varies. Multiple regression analysis was used. To determine whether a significant relationship exists between the dependent variable and the set of all the independent variables, the Analysis of Variance of Multiple Regression was used. The procedure for determining the formula to solve for multiple regression coefficients is similar to that of solving for simple regression coefficients. The formulas are established to meet an objective of minimizing the sum of squares of error for the model. Hence, the regression analysis shown here is referred to as least square analysis. The prototype has sensors and LEDs as source circuit. It is composed of eight sensors (phototransistors), eight sources (LEDs) with four colors which are blue, green, yellow and red, and each sensor has an amplifier to amplify the output voltage. Two LEDs were used for each of the wavelengths. Moreover, eight phototransistors were also used to know the light intensity indirectly. Moreover, getting the mean of the output voltages of the sensors was an advantage for the design. The charge controller circuit was used to cut off the supply from the solar panel when the battery is fully charged to avoid overcharging and to start charging when battery voltage drops off a certain value. In this research, the maximum allowed voltage is 9 volts, and the minimum voltage is 7.5 volts. The preferred voltage rating of the battery is 8 volts lithium-ion battery.

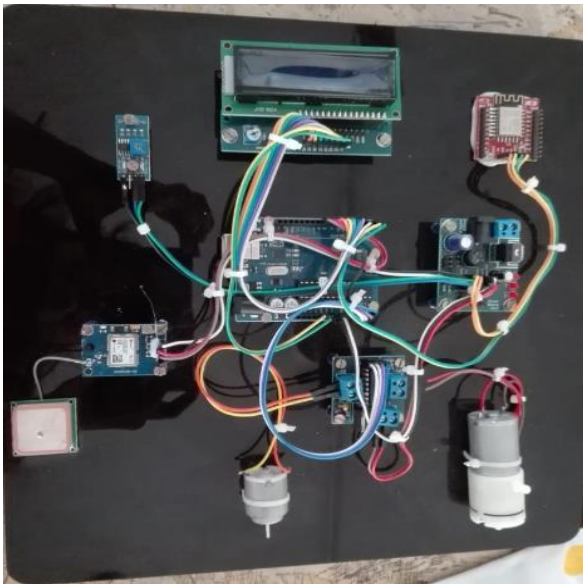

Fig 7. Experimental Setup

CONCLUSION

Oil spill pollution persists in a marine environment or inland water across the world has greatly affected the many marine resources because of its late detection and identification of how hazardous the Oil Spill is based on its thickness. Therefore, an immediate approach of designing a device addressing the issue in determining its hazardous level thru its thickness is necessary. The paper has determined the pixel intensity concerning several parameters like the wavelength of the pixel source and thickness of an oil spill. The LEDs (Pixel Emitting Diodes) are used as a pixel source, and Phototransistor sensors are used to estimate the intensity of the pixel. Using various parameters, the paper had able to establish a mathematical modeling of its pixel intensity connecting it to the hazardous identification of the oil spill thickness involved. There were various wavelengths utilized to compare its result. The modelling equation for the pixel intensity. This study has also become beneficial to the government and people as they will be able to determine in real time the spread of the oil spill. By understanding this proposed solution, the direct effect of the oil spill will decrease as it will bridge knowledge gaps to improve the government and private sector response in cleaning this marine pollution.

REFERENCES

[1] Jha, M. N.; Gao, Y., "Oil spill contingency planning using Laser Fluorosensors and web-based GIS," OCEANS 2008, vol., no., pp.1,8, 15-18 Sept. 2008

[2] Assilzadeh, H.; Gao, Y., "Oil Spill emergency response mapping for coastal area using SAR imagery and GIS," OCEANS 2008, vol., no., pp.1,6, 15-18 Sept. 2008.

[3] Chase, C.R.; Van Bibber, S.; Muniz, T.P., "Development of a non-contact oil spill detection system," OCEANS, 2005. Proceedings of MTS/IEEE, vol., no., pp.1352,1357 Vol. 2, 17-23 Sept. 2005

[4] Wu Dan; Shen Jifeng; Zhang Yongzhi; Zhao Pu, "Application of the Marine Oil Spill Surveillance by Satellite Remote Sensing," Environmental Science and Information Application Technology, 2009. ESIAT 2009. International

Conference on, vol.1, no., pp.505,508, 4-5 July 2009

[5] Wei Pei; Yong-ying Zhu, "Wavelet transform based edge detection of marine oil spill image," Automation and Logistics, 2008. ICAL 2008. IEEE International Conference on, vol., no., pp.470,475, 1-3 Sept. 2008

[6] Massaro, A; Lay-Ekuakille, A; Caratelli, D.; Palamara, I; Morabito, F.C., "Optical Performance Evaluation of Oil Spill Detection Methods: Thickness and Extent," Instrumentation and Measurement, IEEE Transactions on, vol.61, no.12, pp.3332,3339, Dec. 2012

[7] Zhao Qingling; Li Ying, "Monitoring Marine Oil-spill Using Microwave Remote Sensing Technology," Electronic Measurement and Instruments, 2007. ICEMI '07. 8th International Conference on, vol., no., pp.4-69,4-72, Aug. 16 2007-July 18 2007

[8] Peng Chen; Ying Li; GuoxinLan; Bingxin Liu; Hui Zhou, "Oil Spills Detection and Monitoring Using Airborn Thermal Infrared Remote Sensing in Dalian Xingang Oil Pipeline Explosion," Remote Sensing, Environment and Transportation Engineering (RSETE), 2012 2nd International Conference on, vol., no., pp.1,4, 1-3 June 2012

[9] Suo Yong-feng; Chi Tian-He; Peng Ling, "Review on the Key Technology of Real-Time Oil Spill Monitoring System Based on Marine Radar," Remote Sensing, Environment and Transportation Engineering (RSETE), 2012 2nd International Conference on, vol., no., pp.1,4, 1-3 June 2012

[10] Grimaldi, C. S L; Casciello, D.; Coviello, I; Lacava, T.; Pergola, N.; Tramutoli, V., "Satellite oil spill detection and monitoring in the optical range," Geoscience and Remote Sensing Symposium (IGARSS), 2010 IEEE International, vol., no., pp.4487,4490, 25-30 July 2010