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DEVELOPMENT OF A FLOATING SURFACE WATER ROBOTIC OIL SPILLAGE SURVEILLANCE (SWROSS) SYSTEM

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ABSTRACT

The severity of an oil spill's impact depends on how quickly it is detected when spills occur. The location where they happen, oil spills have a significant effect on the economy, ecology, health, and society. In the detection of spills, several techniques have been used, such as real-time remote observation by flying aircraft with surveillance crews to stop oil bunkering and vandalism in the Obotobo and Ogulagha communities in the Niger Delta region in Nigeria. This paper focuses on developing a floating surface water robotic oil spillage surveillance system. The designing of the system consists of hardware and software components, the hardware components are an Arduino Wemos D1 board, a Wifi camera, a battery, solar, a Node microcontroller unit, and wheel chassis. The development was aided by the following software: Arduino IDE, Blynk IoT platform, and a Windows 10 Operating System. Software development involves the prototype approach and the C++ programming language. The Alpha Test method was used to test and evaluate the system. The result reveals a fast notification of oil spill alert message sent to the device receiving the notification located in the base station whenever an oil spill is detected. This paper is recommended for oil companies to effectively monitor and manage oil leakage.

Keywords: Oil spillage, surveillance, sensor, and Buoy

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1. INTRODUCTION

Oil spills, which result from leaks from ship discharges, oil platform discharges, and oil tanker problems are presently one of the world's essential pollutants problems. Oil reaches the world's oceans through natural seeps from an underwater hydrocarbon deposit as well as land-primarily based total sources which include transport accidents and offshore oil fields. The oil may finally be carried to the coast by the sea currents. It will be a big crisis for the health of the aquatic environment and also the livelihood of the people (Mark et al., 2016).

A vast marine oil leak has cost the nation economic losses, but it has also seriously harmed the ecosystem. Regarding the Gulf of Mexico oil spill (Cui and Zhang, 2018), those oil spill events caused damage to the local marine ecosystem and caused serious economic, ecological, and social impacts. In addition, the oil spill area will spread to other places with the current and wind and eventually affect a large area of the sea. Furthermore, polluted marine organisms will enter the human body through the food chain, leading to a variety of diseases and even casualties (Tao, 2015). Remote sensing monitoring provides a lot of technical support for oil spill risk inspection, oil spill pollution monitoring, early warning, emergency response, oil spill ecological damage assessment, and remediation (Sun, 2019).

Two methods used in the Niger Delta region of Nigeria in detecting crude oil spills: pipeline pressure monitoring and human surveillance teams. A pressure monitoring method cannot readily pick up oil spills from the crude oil pipeline promptly. The human surveillance teams report oil spills when they physically observe in their jurisdiction, and these reports occur after environmental damage has occurred O'tega et al, (2020).

This paper presents the design, development, and testing of the SWROSS system for detecting crude oil spills on surface water. The SWROSS system design is in the Materials and Methods Section. The SWROSS system was successfully tested on surface water in the Obotobo community, Burutu LGA, Nigeria. The system performance evaluation is presented in the system evaluation section. The challenges encountered are highlighted in the conclusion sections as well as the significance of the system and its application areas.

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2. MATERIALS AND METHODS

2.1 MATERIAL

Hardware Components

1. Arduino Wemos D1 board: The WeMOS d1 which is an Arduino compatible board with the built-in ESP8266 Wifi Module. WeMos D1 Arduino compatible development board is the cheapest WiFi-enabled board available today. It is a WiFi enabled based on the ESP8266 chip. The board looks like an ordinary Arduino board. The dimensions and the pin layouts are exactly the same. So, this board is compatible with all the existing shields for Arduino.

Figure 2.1: Arduino Wemos D1 board

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2. Motor drive shield: The Motor Shield is a driver module for motors that allows you to use Arduino to control the working speed and direction of the motor. Based on the Dual Full-Bridge Drive Chip L298, it is able to drive two DC motors or a step motor.

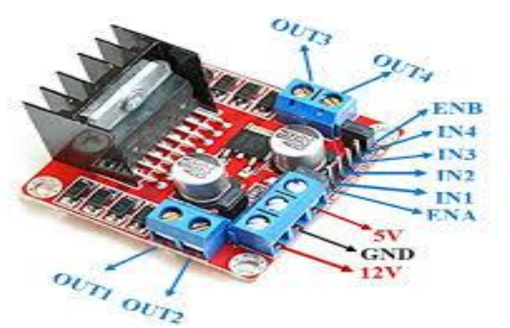

Figure 2.2: Motor drive shield

3. Node MCU: The NodeMCU (***N***ode ***M***icro***C***ontroller ***U***nit) is an open-source software and hardware development environment built around an inexpensive System-on-a-Chip (SoC) called the ESP8266. The ESP8266, designed and manufactured by Espressif Systems, contains the crucial elements of a computer: CPU, RAM, networking (WiFi), and even a modern operating

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system and SDK. That makes it an excellent choice for Internet of Things (IoT) projects of all kinds.

Figure 2.3: Node MCU

4. Wheel Chassis: This chassis comprises of Wheels, Motors, Frame, bolts and nuts, battery pack and wires. They are assembled together to build a framework of the robotic car.

Figure 2.4: Wheel Chassis

5. MQ-5 Sensor: MQ-5 sensor has high sensitivity to Methane, Propane and Butane, and could be used to detect both Methane and Propane. The sensor could be used to detect oil spillage and gas leakage.

Figure 2.5: Sensor

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6. Battery: 18650 batteries are lithium-ion batteries. They get their name from their size: 18mm by 65mm. These batteries not only used in flashlights, but also in: power tools, electric vehicles, vaporizers, cameras, laptops, and more.

Figure 2.6: Lithium-ion battery

7. Wifi Camera: WiFi Camera with Night Vision, HD 1080P Video & 150° Wide Angle Lens: With 150 degree wide angle lens, the mini spy camera allows you to see more details happening in the room. The quality lens also features 1080P video and pictures that perfect surveillance camera for your Office or business place.

Figure 2.7: Wifi camera

8. Solar Power: The solar is 7.2 volts and a size of 4.5m.

9. Casing and Floater: Casing: Length 8 Inches, Width 6 Inches and Height 3 Inches. Floater: Length 7 Inches, Width 5Inches and Height 1 Inch.

The Software used for the development of this study is:

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i. An Operating System (Windows 10 Operating System)

ii. Arduino IDE

iii. Blynk

The methodology adopted for this paper is the Prototyping methodology. The Prototyping methodology is a system development method in which a prototype is built, tested, and then reworked as necessary until an acceptable outcome is achieved from which the complete system can be developed.

Phases of the Prototyping Model include:

1. Requirements Identification: Obtain a list of the key criteria that determine the need for the new system, including the key input and output data.
2. Develop initial prototype: Develop a basic initial prototype that only has UI screens.
3. Review the prototype: End users and SMEs work and examine the prototype and provide feedback for improvements/enhancements.
4. Revise and enhance the prototype: The scope is changed based on feedback from end users and the prototype is enhanced and refined to accommodate user feedback.

2.2 METHODS

The study methodology consists of the following phases: documents review of existing oil spill surveillance systems, the hardware components of the proposed system including Arduino Wemos d1 board, Node Mcu, Motor drive shield, Wheel Chassis, MQ-5 Sensor, Batteries and Solar, the software used for the developing the SWROSS system are Arduino IDE, Blynk IoT platform and a Windows 10 operating system, the development of the system, testing, and evaluation of the proposed system.

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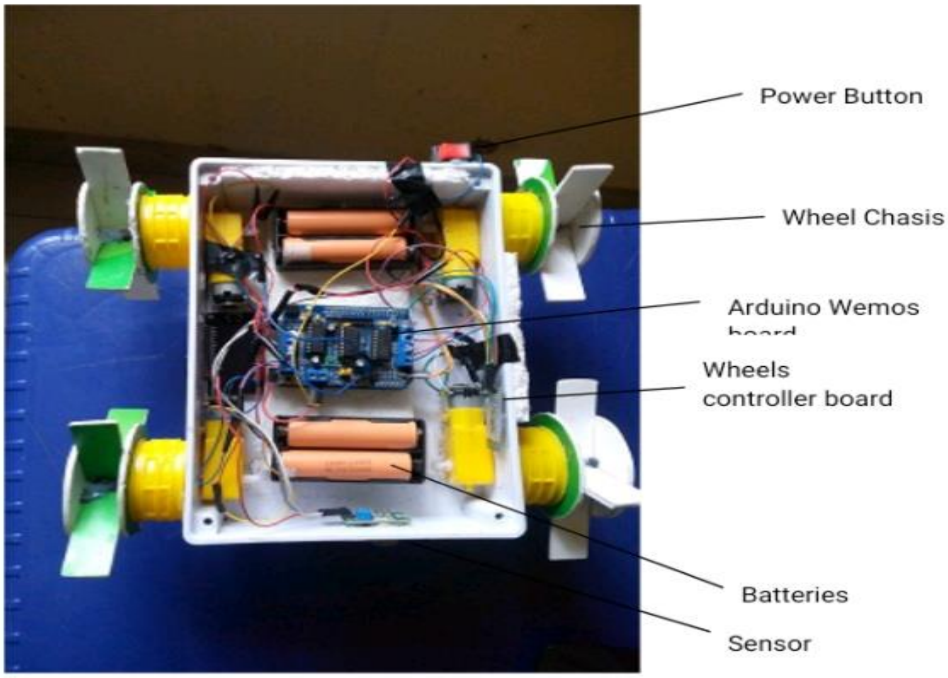

Figure 2.8: Design connection of SWROSS system

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Figure 2.9: Physical Design of Surface Water Robotic Oil Spillage Surveillance (SWROSS) system.

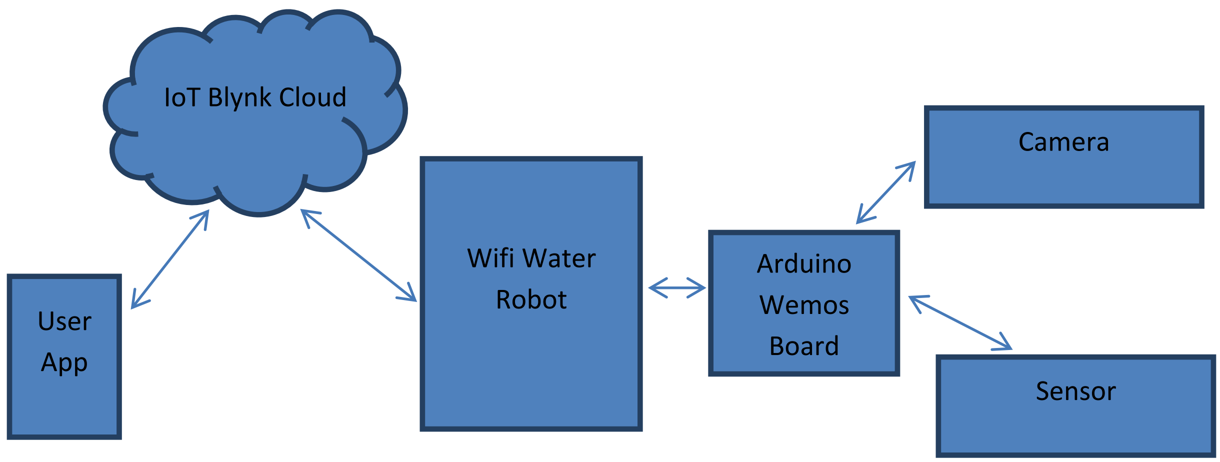

Figure 2.10: Design Architecture of the SWROSS System

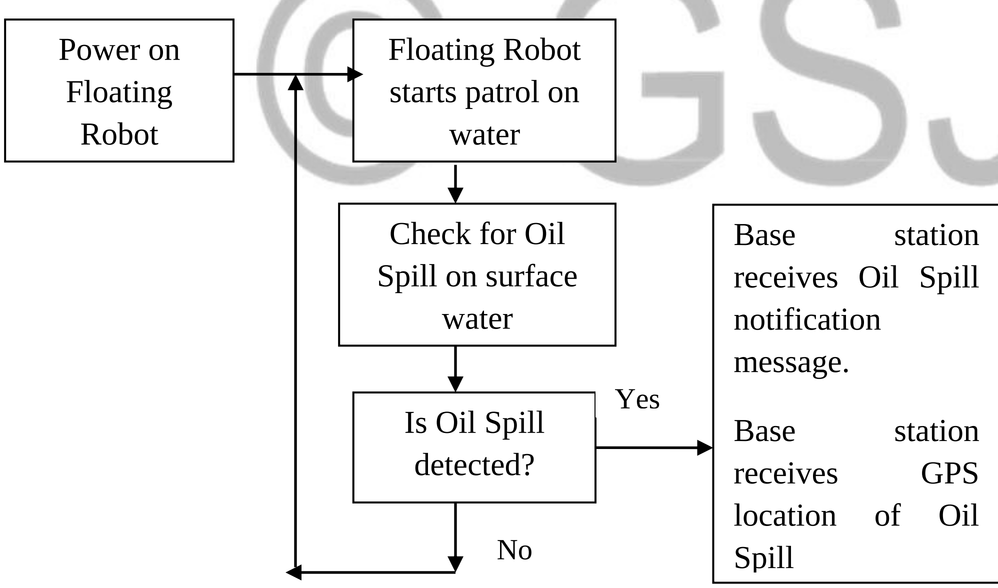

Figure 2.11: Operation of the proposed SWROSS System

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Pseudo code for the designed Floating Surface Water Robotic Oil spillage Surveillance System

Begin

Read data from MQ-5 sensor

If *sensor data value* exist then

Show the gas/methane value

Display "Data Readings" in interface

If the *gas value* is greater than 300^0 then

Display notification "Oil Spill Detected"

End if

Else if the *gas value* does not exists then

Check connections

End if

Check Oil Spill Robot connection

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If connection okay == yes

Move robot forward

Move robot backward

Move right and left

Else

Check connections and turn robot on

Check camera

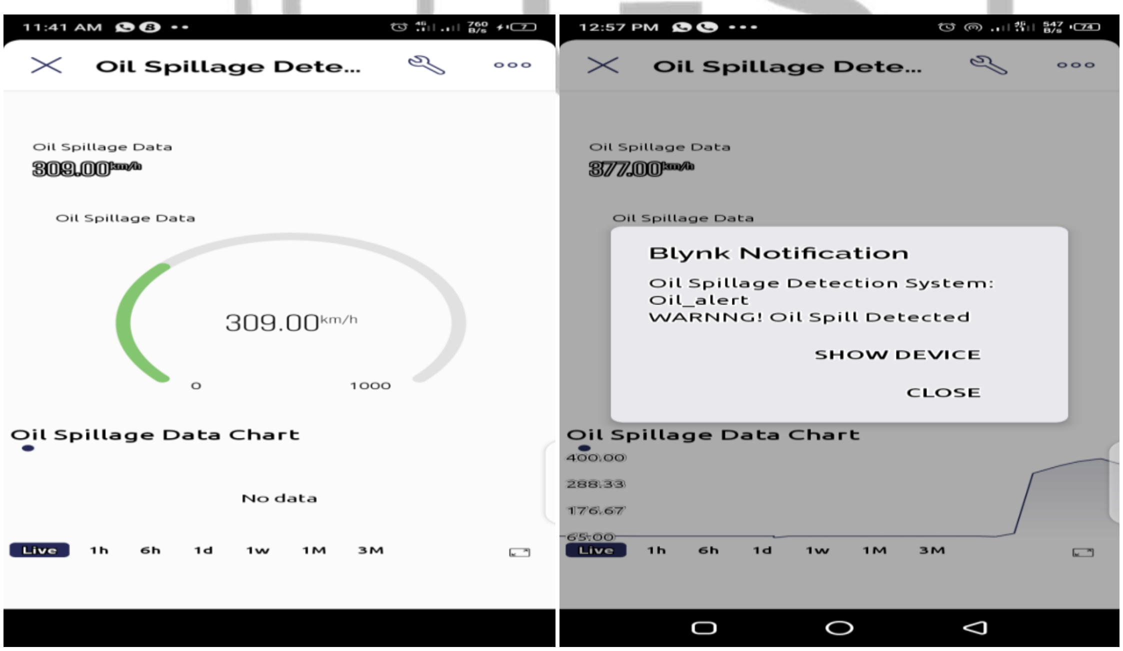
Is camera connected?

Yes: View camera footage

No: turn on camera

End

SWROSS System Notification Interface



(a) *(b)*

Figure 2.12: Oil Spill notification Interface

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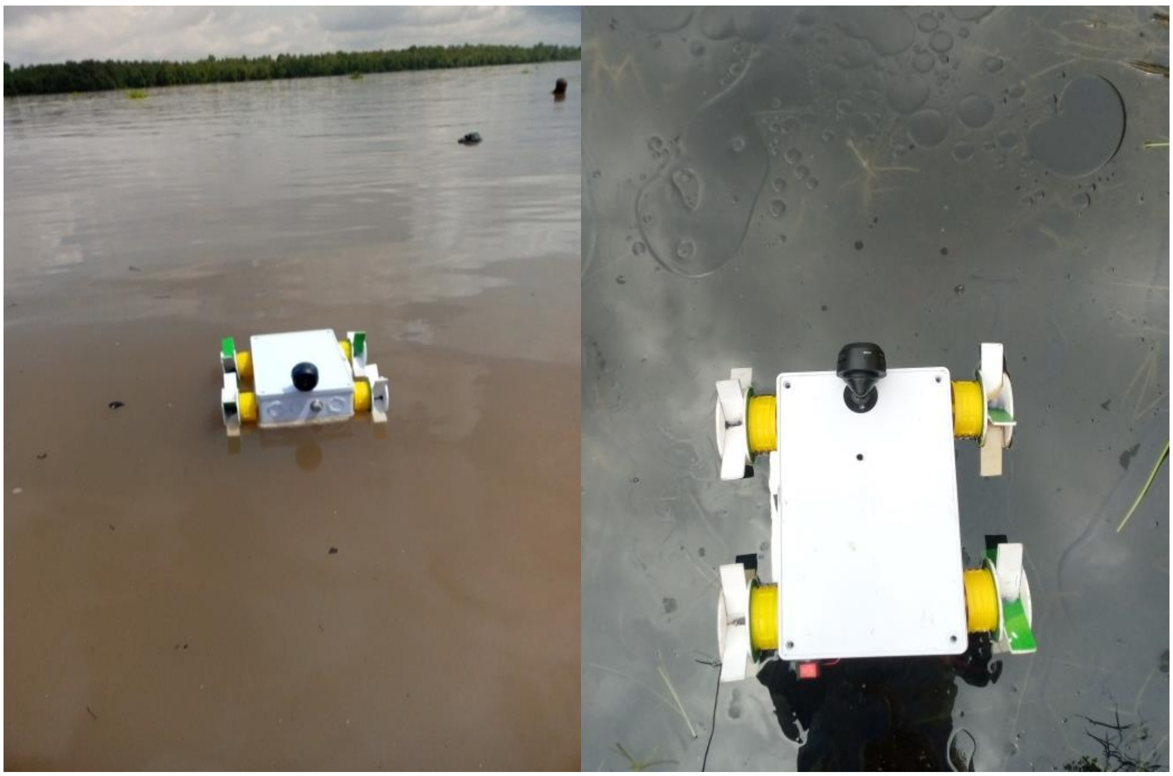
SWROSS System Testing

The SWROSS is controlled manually using Wireless control to provide constant surveillance over 60m on surface water. A patrol time of approximately 8 minutes was sufficient to ensure a surveillance distance of 60m. The battery voltage for each battery is 3.3V; the SWROSS has 4 Lithium-ion batteries to enable sufficient power during the patrol period and the solar to enhance the battery power during patrol. Approximately 1 liter of crude oil was poured on surface water in the surveillance route to determine if the SWROSS system will be able to detect the simulated crude oil spill during its patrol. During the patrol, floating obstacles were placed on surface water along the patrol route to test the system's Wifi camera if it can successfully detect and avoid obstacles along its surveillance route.



(a) *(b)*

Fig 2.13: SWROSS system during patrol. SWROSS system in contact with Crude Oil

Figure 2.13a shows the SWROSS system patrolling 60m on surface water and Figure 2.13b shows SWROSS patrolling on surface water with a simulated crude oil of approximately 1 liter placed on the surveillance path. The base station was located approximately 80m away from the surveillance route. The device receiving the spill notification was also in the base station.

The SWROSS system starts patrolling on the surface water while simultaneously checking for crude oil spills using the MQ-5 sensor. If the SWROSS system detects oil spills, it takes pictures of the spill site, images and GPS location of the oil spill and is sent wirelessly to the host device

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(notification receiver) at the base station and oil spills can be confirmed from acquired images. During the patrol, the SWROSS system constantly checks to ensure that there are no obstacles via its Wi-Fi camera. The SWROSS system is programmed to detect oil spills on surface water and avoid obstacles along its surveillance path through its mounted Wi-Fi camera.

The performance parameters of the SWROSS system are:

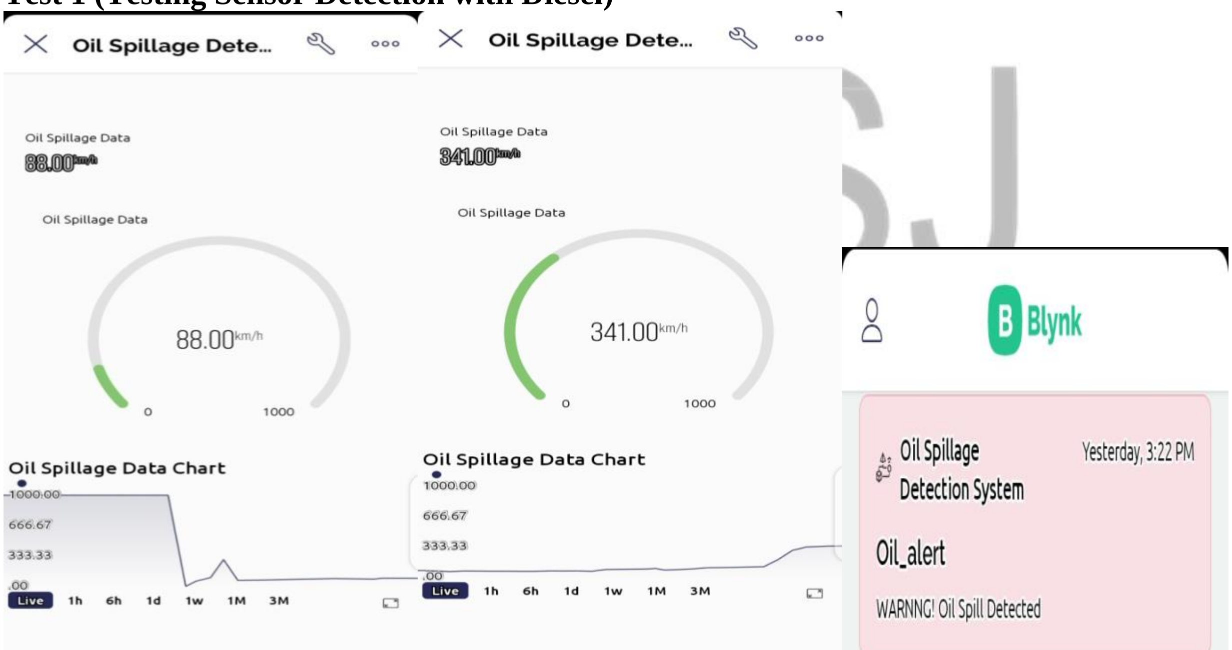
1. Efficiency: The ability of the system to float on surface water.
2. Sensitivity: The ability of the system to detect oil spills on surface water using the MQ-5 sensor.
3. Sensitivity: The ability of the system to detect and avoid obstacles along its surveillance route with the aid of Wifi camera.
4. Response Time: The ability of the system to wirelessly send GPS location and pictures of Oil spill sites to the notification receiver system in the base station.

3. RESULTS

SWROSS System Performance Evaluation

In the testing of the SWROSS system, sensitivity and response time were the metrics used. Evaluation metrics measured sensitivity to changes in environment and response time.

Test 1 (Testing Sensor Detection with Diesel)



(a) Before contact with Diesel (b) After contact with Diesel (c) Oil Spill received notification

Figure 2.14: SWROSS system output before and after contact with Diesel

Test 2 (Testing Sensor Detection with Fuel) (Sensitivity)

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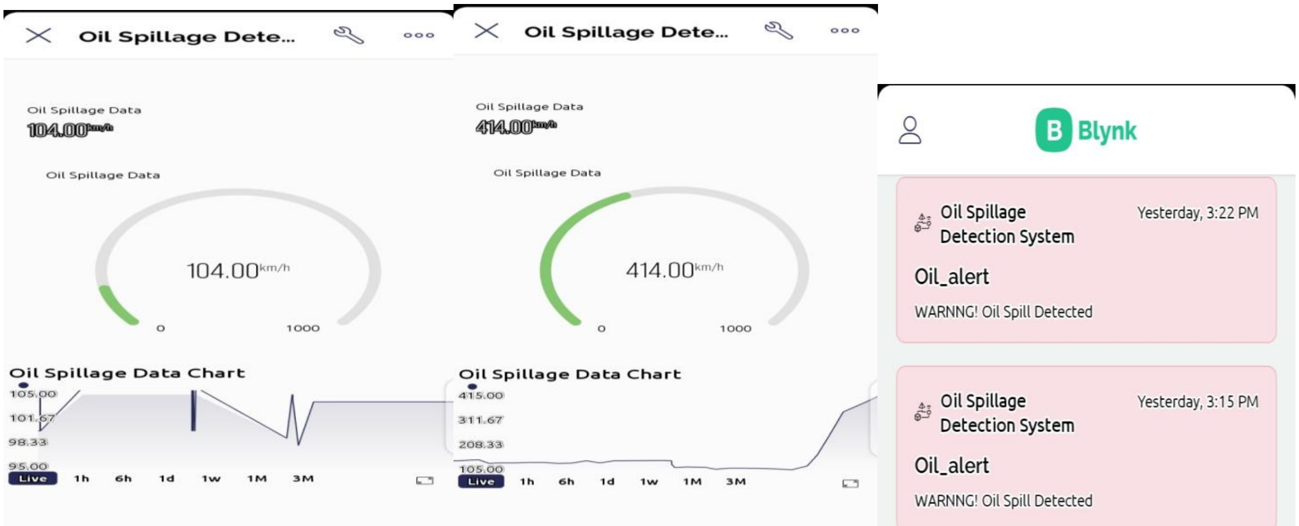
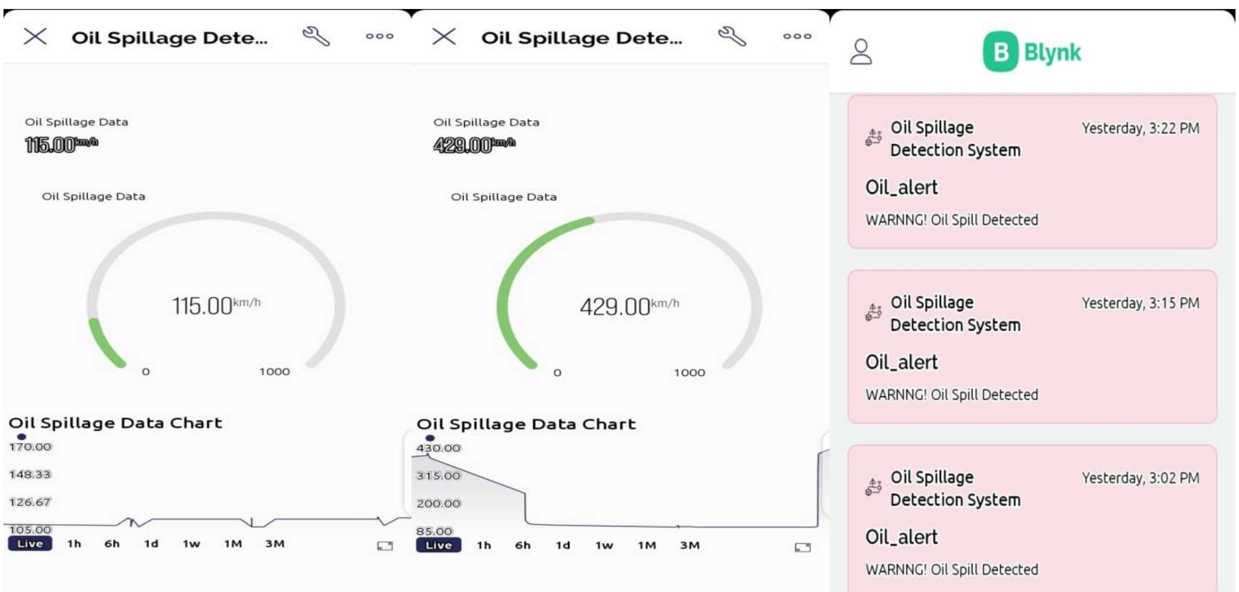


(a) Before contact with Fuel (b) After contact with Fuel (c) Oil Spill received notification
Figure 2.15: SWROSS system output before and after contact with Fuel

Test 3 (Testing Sensor Detection with Gas)



(a) Before contact with Gas (b) After contact with Gas (c) Oil Spill received notification
Figure 2.16: SWROSS system output before and after contact with Gas

Test 4 (Testing Sensor Detection with Crude Oil)

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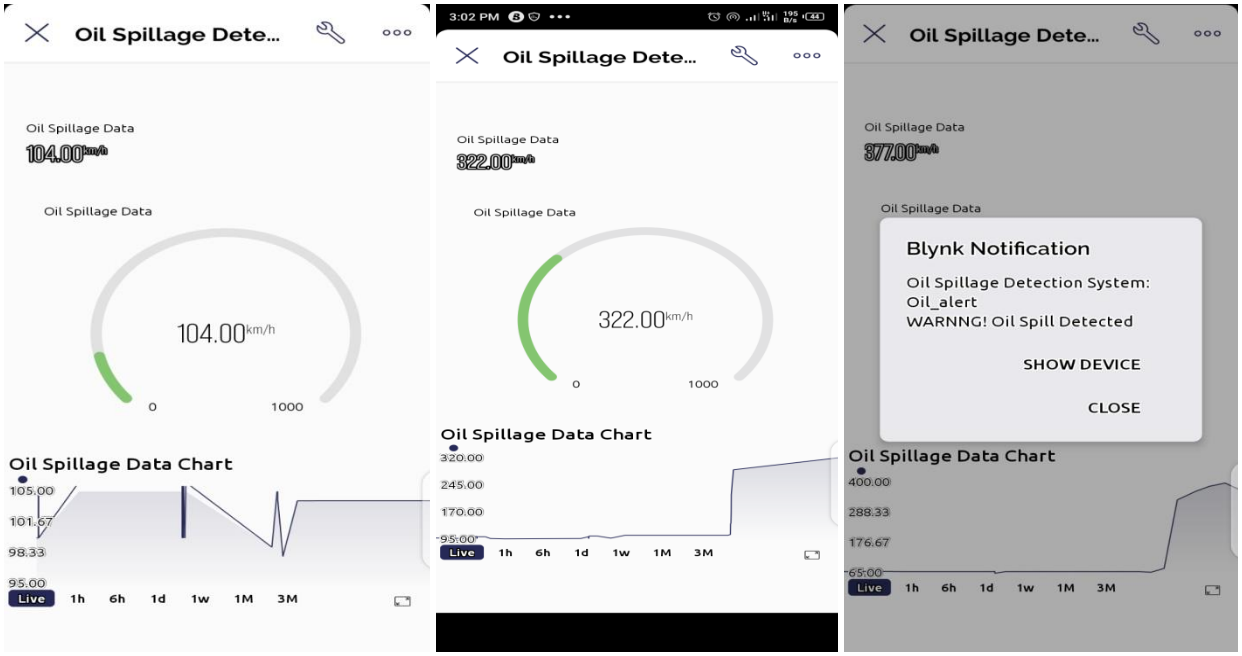

(a) Before contact with Crude Oil (b) After contact with Crude Oil (c) Oil Spill received notification

Figure 2.17: SWROSS system output before and after contact with Crude Oil

Oil Spill Surveillance and Detection

Crude oil approximately 1 liter was poured on surface water along the surveillance route of the SWROSS (see Figure 2.14b). Figure 2.14a shows the SWROSS system during patrol and detecting the simulated crude oil spill via the described method in the materials section of this paper. When oil spill is detected, the SWROSS system wirelessly sends the captured image and the GPS location of the spill site to the notification receiver at the base station. Figure 2.13b shows the wirelessly transmitted spill detected notification message to the notification receiver located at the base station.

4. Conclusion

Adding intelligence to oil spill surveillance makes detection real-time and provides insight into combating pollution in the future. The Surface Water Robotic Oil Spill Surveillance (SWROSS) system was designed to detect crude oil spill on surface water. The system was able to patrol 60m of surface water in Obotobo River, Burutu local government, Delta state, Nigeria in 8 minutes. Gathering raw data triggered by an event gives minimal insight into crucial facts like the thickness of the oil, and the expanse of the oil spill and also reduces the number of redundant transmissions.

The SWROSS system detected 1 liter of crude oil spills, captured images of the spill site and transmitted the spill GPS location and oil spill notification to the notification receiver (device) at the base station 80m away from the surface water within 2seconds. Adding intelligence to

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sensor nodes to decide on oil spills can be considered for future enhancement. If this system is successfully implemented and used to detect crude oil spills. The system will aid in reducing crude oil leaks brought on by theft and vandalism, safeguard the environment, help boost the socioeconomic conditions of indigenous communities, reduce the likelihood of bunkering activities, and protect the government and petroleum companies from economic losses due to oil spillages.

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