OIL SPILL CLEANING DEVICE USING RASPBERRY PI

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ABSTRACT

The Smart Oil Saver is an innovative prototype device designed to address the issue of oil spills in marine environments. The prototype is equipped to detect oils from the surface area of water using webcam and machine learning. The prototype device was utilized using the Raspberry Pi, serving as the main processing unit. The prototype device was successfully developed using the hardware which includes TFT Touchscreen LCD, Water Pump, A9G module, Relay, Webcam. It also integrated machine learning algorithms by using Microsoft LOBE, TensorFlow and Python Language to enhance the device for its efficiency and effectiveness in oil detection and deploying chemical dispersant. First, it detects oil spillages using high-resolution web camera. The data collected are then processed by sophisticated machine learning models, which accurately distinguish between oil and water. Once the oil is identified, the Smart Oil Saver deploys the oil dispersant. These components are designed to maximize oil retention while minimizing water uptake, ensuring efficient clean-up. Using the TUP Evaluation Instrument for prototype development, 30 professionals participated in the evaluation. The evaluation results indicated that the prototype device is "Very Acceptable" with a grand weighted mean of 3.48 which proves that the Smart Oil Saver can be helpful in future oil spill response.

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THE PROBLEM AND ITS SETTING

Introduction

Oil spills give rise to a consequential threat to the environment, marine life, and shoarline ecosystems. These incidents frequently have long-term ecological and economic effects. It is critical to develop efficient and innovative methods for cleaning up oil spills to reduce the damage they cause to the environment. The advancement of technology and machine learning has created new avenues for addressing this critical issue.

In response to the need for an improved oil spill cleanup solutions, the researchers came up with the concept of having a "SMART OIL SAVER (SOS)," a cutting-edge device designed to solve oil spill problems. SOS is based on ARM technology and uses machine learning algorithms to improve its oil spill cleaning capabilities. This hardware device represents a promising approach to addressing one of this generation's most pressing environmental challenges.

In the sections that follow, the researchers delved deeper into SOS's design and functionality, looking at how it uses machine learning techniques to detect and remove oil spills efficiently. Also discussed its potential impact on environmental conservation efforts, as well as the implications for future developments in oil spill cleanup technology.

Background of the Study

Oil spill is known as an marine biodiversity disaster affecting the ecosystem causing the death of sea plants and animals. In addition, contamination of water is possible which may affect the quality of water and making it unsafe for both marine life and human consumption. Technological disasters such as oil spills adversely distress and “destroy the bio-physical environment through the breakdown of technological processes and systems” (Flagg, 2017). According to International Tanker Owners Pollution Federation (IOTPF), data show that seven oil spills of more than seven tonnes were recorded from tanker incidents in 2022. ITOPF has recorded tanker spill statistics over the last 50 years and in this time, despite of some annual fluctuations, the number and volume of oil spills from tankers has dropped dramatically. These numbers are stabilizing at a low level, with the reduction being driven by positive change from the shipping industry. February 2023, the province of Oriental Mindoro faced threats because an oil spill incident happened in the vicinity of the municipality of Naujan. The oil tanker MT Princess Empress sailed from Bataan bound for Iloilo, carrying 800,000 liters of industrial oil. Unfortunately, the oil tanker sank in Naujan and has resulted in an oil spillage on multiple areas and shorelines in the waters of the province of Oriental Mindoro and nearby provinces such as Palawan and Antique. According to Naujan Municipal Planning and Development Office, the disaster affected fishing communities, marine protected areas, and ecological sanctuaries. Along this area lies the Verde Island Passage, which is a global center of marine biodiversity (Gevaña et al. 2022).

According to Coast Guard LTJG Gerald Cordero, oil spill incident will not immediately be responded. The method used to clean up the problems with oil is based on different marine elements such as the oil type, salinity of water, and environmental sensitivity. Persistent oils, such as heavy crude, do not evaporate quickly and can remain in the environment for long periods, causing extensive and prolonged damage. In contrast, non-persistent oils evaporate more rapidly but can still pose immediate threats to marine and coastal ecosystems. Additionally, the weather characteristics of oil should also be known because once the oil spreads in the environment, it undergoes different changes like it directly evaporates or emulsify the oil volume four to five times. Weather conditions, such as wind and waves, can spread the oil and impact the effectiveness of different methods. Various cleanup methods have been developed and refined over the years, each suited to specific types of spills and environmental conditions. Mechanical methods, such as booms, physically take off the oil from the marine environment and are effective for large spills. Chemical methods, including dispersants and solidifiers, reduce the oil to tiny particles or solid masses, making it easier to manage and decompose.

However, traditional oil spill cleanup methods, for example booms and skimmers require substantial manpower for effective operation which may cause errors and delays in responding to an oil spill incident. It is also apparent that remediation of an oil spill cannot be considered a one-time event, but rather involves ongoing monitoring of the area where the disaster happened. To implement a necessary action plan, detailed information must be collected from the spill site.

Machine learning has appeared as an effective tool for improving the detection. This study focused on the integration of machine learning techniques into the domain of oil spill management. In doing so, machine learning not only enhances the capacity to respond effectively to oil spill incidents but also reduces the ecological and economic toll of these disasters.

As a step towards attenuating the issues, the researchers proposed a solution to help the oil spill problem. A prototype device that combines ARM-based technology with machine learning capabilities to help people clean up oil spills in the sea by detecting the spill and then releasing a water-based dispersant to eliminate it from the environment.

Objectives of the Study

General Objective

The main objective of the project is to develop a cleaning device that can detect and remediate oil spill using Machine Learning.

Specific Objectives

Specifically, the study aims to develop the following characteristics:

1. The following are the design and features of the Smart Oil Saver (SOS): arm-based oil spill cleaning device using machine learning:
    - The device uses live video stream to record the condition of the environment at the accident site.
    - The A9G (GSM) will send a message to the user/responder about the detection of oil.
    - The prototype device is powered by 12 volts lead acid battery and solar panel.
    - Integrate the device with the ability to detect oil spill via a computer vision-based machine learning model.

2. Create the device using machine learning to detect and deploy with the following development tools:
    - Hardware Tools
        - Raspberry Pi 4 Model B
        - Touchscreen (TFT 7 inch)
        - A9G GSM
        - Webcam
        - Water Pump
    - Software
        - Microsoft LOBE
        - TensorFlow
    - Programming Language
        - Python
3. Test and improve the prototype device.
4. Evaluate the level of acceptability of the prototype device using the TUP evaluation instrument for prototype developed.

Scope and Limitations of the Study

This study aimed to develop a prototype oil spill cleaning device using machine learning. This project aimed to help mitigate and remediate the damage cause of oil spill to the marine environment. The prototype cleaning device was simulated for testing and validation. Web camera, A9G module and the relay for the switch of pump and dispersion, are all connected to the Raspberry Pi. The device is equipped with a Machine Learning model trained to automatically detects the presence of oil on the marine environment and deploy the dispersants. Moreover, deployment of dispersant only starts by the turning on of the relay and the pump will follow. After pump is activated, the liquid is forced down the tube by the submersible pump in the tank. Raspberry Pi equipped with a camera is used for streaming live video of the environment, enabling the professionals to watch the footage in real time action. Once the code is executed, the professionals will be able to witness the live stream of oil accident. The prototype device will also use the A9G to transmit an alert message regarding the discovered oil.

While the device employs an innovative approach to oil spill cleanup, it is important to acknowledge certain limitations with the prototype oil spill cleaning device. The feasibility of deploying the device on a broad scale in an oil disaster geographical area poses a considerable issue. The device's size and weight must be carefully examined to be easily transported to the spill location. Furthermore, the potential for unforeseen consequences of its cleaning process, which employs dispersants, should be thoroughly evaluated to ensure that the advantages outweigh the environmental impact. Likewise, the choice of dispersant chemicals must be chosen with the least environmental impact.

Chapter 2

CONCEPTUAL FRAMEWORK

This chapter presents a review of related literature, related studies, the conceptual model of the study, and the operational definition of terms.

Review of Related Literature

This section provides an outline of the key principles, concepts and ideas about the subject matter of the study.

Innovative Oil Spill Cleanup Solutions in the Philippines

According to Dr. Dela Cruz (2020), traditional cleanup methods frequently fall short of effectively addressing the vast and intricate nature of oil spills. This is where innovative solutions like the SOS device come in, providing a holistic and dynamic approach that aligns with the environment's complex needs. As climate change and increased global shipping traffic increase the risk of oil spills, embracing and investing in innovative cleanup technologies becomes not only a necessity, but also a moral obligation to protect the Philippines' natural treasures.

The Philippines' marine life and ecosystems represent a priceless legacy that transcends mere ecological value. The Smart Oil Saver (SOS) device ushers in a new era in the fight against oil spills, demonstrating the power of innovation in protecting these fragile ecosystems. The importance of embracing and supporting innovative oil spill cleanup solutions cannot be overstated as the Philippines moves toward sustainable development. By doing so, Filipinos honor and preserv the intricate tapestry of marine life that defines the nation for future generations.

Government Agency Responsible for Policies

According to De Guzman (2021), the Philippine Coast Guard (PCG) plays a critical role in responding to and managing oil spill incidents. The PCG has different departments specifically for marine environment, the Marine Environmental Protection Command or MEPCOM, which includes another one specifically for oil spill clean-ups, the National Operations Center for Oil Pollution. These departments are contact persons for oil spill response operations. This agency is in charge of coordinating cleanup efforts, mitigating environmental damage, and holding those responsible accountable.

Existing Techniques for Oil Spill Cleanup at Sea

Oil spills continuously to be a large issue for the marine environment. Most marine transportation of different products throughout the world, and import and exportation for oil from maritime assets is increasing. Nonetheless, most oil spills are unintentional, making it increasingly vital to apply alternative cleanup measures to mitigate the threat they may bring to the marine ecosystem (Agarwal, 2021).

Oil Booms

These are the simplest ways of containing an oil spill. They are used as a fence to keep the oil in a specific location and avoid from spreading away with the chance of affecting other marine lives.

In-Situ Burning

It involves igniting the oil to destroy it. While this method reduces the volume of oil quickly, it also introduces air pollutants and toxic fumes into the atmosphere. Furthermore, its viability is limited by environmental concerns and its impracticality in sensitive habitats.

Chemical Dispersants

Chemical Dispersants disperse oil by breaking it down into little particles that float around in the water. While they hasten biodegradation, they endanger marine life and may not address the underlying issue of oil pollution. The possibility of unanticipated long- term consequences highlights the method's limitations.

Bioremediation

Bioremediations are used on microorganisms to degrade oil. Despite its eco- friendly premise, it is based on complex characteristics such as temperature, microbial availability, and water environment. Its relatively slow on top may be insufficient in mitigating large, rapid spills.

Limitations and Inefficiencies of Existing Methods Experience

Existing cleanup methods experience have several limitations that limit their effectiveness:

Ecological Impact

While cleanup methods are critical for reducing oil pollution, they can inadvertently harm marine life and sensitive habitats. Chemical dispersants, for example, can change the formation of oil and make it a little particles, but these chemicals also have chances to have negative effect to aquatic organisms. Furthermore, physically removing oil can disrupt marine environment, which is also important habitats for a variety of species.

Weather Constraints

Many oil spill response techniques, such as skimmers, are heavily reliant on good weather. High winds, rough seas, or bad weather can reduce their effectiveness, making deployment difficult during storms or bad weather. This limitation may cause cleanup efforts to be delayed and the oil to spread further.

Residual Pollution

Even after extensive cleanup efforts, traces of oil frequently remain in the environment. These toxins can continue to be released and have long-term ecological consequences. Residual oil can also sink and become buried in sediment, making removal difficult and contributing to long-term environmental degradation.

Time Consumption

Many oil spill cleanup methods are time-consuming, requiring extensive planning and execution. During this time, the oil's impact on marine ecosystems has grown, resulting in greater ecological damage. Because oil can spread or sink over time, a delay in response can reduce the effectiveness of certain cleanup techniques.

Operational Complexity

Coordinating and carrying out cleanup efforts, particularly in remote or harsh environments, presents logistical challenges. Moving equipment, personnel, and resources to remote locations can be difficult and time-consuming. In some cases, the lack of infrastructure and accessibility in these areas complicates response efforts even further.

Scale Mismatch

Existing cleanup methods may be insufficient for large-scale oil spills, as evidenced by notorious historical incidents. The sheer volume of oil spilled can overwhelm available resources and technology, making it difficult to effectively clean the entire incident. Such incidents emphasize the importance of increased scalability and preparedness in oil spill response.

Introduction of Robots to Clean Ocean Oil Spills

Sheco, a South Korean start-up based in Incheon, recently unveiled a series of oil-filtering robots for cleaning up oil spills in the ocean.

According to Kwon (2022), many people used sorbents to clean up oil on the ocean's surface and then burned the sorbents inland. This resulted in unnecessary carbon emissions and had an influence on our health. Sheco Ark is different from other oil extractor products previously introduced to the market.

While some cleaning devices are bulky, weighing 200 to 600 kilograms, Sheco's box-shaped robots, which weigh less than 60 kilograms and are about one-fourth the size of other devices, may also be remotely controlled or operated autonomously, depending on the model. Kwon claimed that developing the final version of Sheco Ark without the assistance of nautical experts was difficult. Kwon founded his company in 2017 and spent the first two years primarily conducting market research.

Dispersant: An Effective Cleanup Solution

Dispersants have emerged as a promising tool in the oil spill response toolbox, providing a mechanism for dealing with the problem of surface oil slicks. Dispersants, with their distinct properties, play an important role in breaking down and dispersing oil, paving the way for a more efficient cleanup process.

Dispersants are chemical agents that aid in the dispersal of oil into smaller droplets when it comes into contact with water. These droplets made by the dispersant is easily mixed reducing the thick slick of the oil, which can harm marine life and ecosystems. Dispersants, in essence, convert a visible slick into smaller, less concentrated particles that are more amenable to natural biodegradation.

Dispersants also work by combining physical and chemical processes. After the dispersants are applied, the tension is reduced, causing the small droplets. These droplets disperse throughout the water column, increasing their accessibility to naturally occurring microbes capable of degrading the oil. Dispersants, by breaking down the slick, raise the possibility at which oil is died by natural processes, reducing the impact on the environment.

The Case of Oil Spill in Guimaras

According to different news, the Philippines experienced one of the worst oil spill problem in the area which happened in in a province of Visayas. It was caused by an oil transportation that sank near the shoreline. It is still considered as the one of the major incident in Philippine history. Taklong Island Marine Natural Reserve (TINMR), a protected location in the area has the worst experience where all the fishes and other species are located.

Responders used human hair and made an oil boom to contain the oil in one location. A nation's effort was launched to request hair. Different businesses and establishments, barbershops from across the region collected hair and delivered it to the province. Along with proper research, human hair was banned because it can also harm the environment.

Figure 1. Oil Spill in Guimaras

According to Dr. Sadaba, it degrades gradually. It is also difficult to recover once it is in the marine environment. The use of the hair of the humans has also been subjected to chemicals used in beauty salons like shampoos and can be a cause as a contaminant. After that, the locals used to make booms made out of different things can be seen easily and other natural materials found around.

The Philippine Coast Guards (PCG), Petron Corporation, and foreign aid cleaned up at sea, mostly utilizing oil spill dispersants (OSDs). OSDs act as a cleaner, taking oil from the water's surface and breaking it down into smaller particles that biodegrade more rapidly and easily, according to the Oil Spill Prevention Response. Sonsub, an Italian oil and gas company, retrieved the remaining oil from the sunken vessel that lay 640 meters (approximately 2,100 feet) underwater using a ship built for oil spill recovery and a ship designed for oil spill recovery. The cleanup of the shoreline and at sea took a year. Responders collected an estimated 282,000 bags (about 2,100 tons) of natural materials used for spill booms as well as recovered oil, which was used as an alternative fuel for cement manufacturing in Mindanao.

Dr. Terence P.N. Talorete, a Filipino research scientist residing in Japan, proposed the use of bioremediation, a procedure that accelerates biodegradation. The hydrocarbon-degrading bacteria that feed on the heavy oil that is put into a contaminated environment are critical to this process. When the oil is depleted, the bacteria die naturally, causing no harm to the environment. Biodegradation in conjunction with remediation was used in the two worst oil spills in US history, the Exxon Valdez oil leak in 1989 and the BP catastrophe and oil spill in the Gulf of Mexico in 2010.

Hardware Devices

Raspberry Pi and Relevance to the SOS Project

According to research of Sai (2020), the Raspberry Pi is a small, cheap and flexible single-board computer (SBC) designed to promote computer science education and to support a variety of DIY projects. Raspberry Pi devices are well-known for their small size, low power consumption, and low cost, making them ideal for a variety of applications in education, hobbyist electronics, and even professional projects.

The Raspberry Pi plays an essential role to the Smart Oil Saver project because it provides a powerful and adaptable computing platform for controlling, monitoring, and improving the capabilities of the oil spill cleaning device. Here are some of the reasons why the Raspberry Pi is important to the SOS project:

Connectivity

Raspberry Pi models are equipped with various connection features, including Wi-Fi, Bluetooth, and USB ports. This enables seamless communication between the SOS device and the user's mobile application, allowing for remote control, real-time data monitoring, and updates.

Control Center

The Raspberry Pi serves as the brain and control hub for the SOS device. It runs the necessary software and algorithms that manage the device's operations, such as navigation, oil spill detection, and cleanup

Data Processing

The Raspberry Pi's processing power enables on-board data processing and analysis. It can process sensor data to make decisions in real-time, optimize cleanup strategies, and log important information for future reference.

Sensors Integration

The Raspberry Pi can interface with different sensors and devices. In SOS project, it can connect to sensors that detect oil spills, monitor environmental conditions, and collect data essential for effective oil spill cleanup.

Automation

With its computational capabilities, the Raspberry Pi can enable automation features in the SOS device. For instance, it can be programmed to navigate autonomously to oil spill locations, initiate cleanup procedures, and return to a designated base or safe location.

User Interface

Raspberry Pi can host a user-friendly graphical user interface (GUI) that is accessible through a mobile application. This GUI allows users to control the SOS device, receive status updates, and view critical data, enhancing the device's usability.

Cost-Effective

Raspberry Pi devices are affordable, making them a budget-friendly choice for projects like the SOS device. This cost-effectiveness is particularly important for educational initiatives and projects with limited funding.

Scalability

Raspberry Pi models come in various configurations, allowing for scalability in the SOS project. Depending on the project's requirements, you can choose the model that best suits the computing power and connectivity needed.

Remote Maintenance

The Raspberry Pi facilitates remote software updates and maintenance of the SOS device. This ensures that the device remains updated with the features and right security without the need of manual assessment. The model used for this project was Raspberry Pi 4 Model B. This device is a popular single-board computer. It is available in several configurations, including models with different amounts of RAM (random-access memory). One of the common configurations in the Raspberry Pi 4 Model B with 4GB of RAM.

Hardware Components of the SOS Device

a. Raspberry Pi board specifications

Some key specifications of the Raspberry Pi 4 Model B with 4GB of RAM are as follows:

- Broadcom BCM2711 quad-core Cortex-A72 (ARMv8)
- 4GB RAM.
- Wi-Fi Ready
- Can be connected to Bluetooth 5.0
- Multiple USB ports.
- HDMI ports that support display at resolutions of up to 4K.
- GPIO (General Purpose Input/Output) pins for hardware interfacing.
- Micro SD card slots for the storage and OS.

- USB-C power supply port.
- 5V DC via USB-C connector
- 5V DC via GPIO header
- Operating temperature: 0 - 50 degrees C ambient

Support for running a variety of operating systems

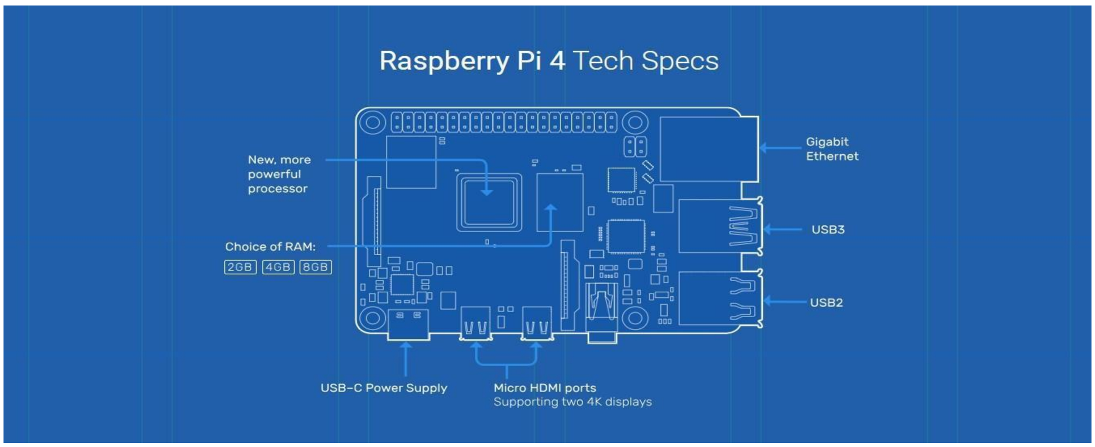


Figure 2. Raspberry Pi 4B Blueprint

Software Components and their Functionalities:

- **Raspberry Pi OS** - Previously called as "**Raspbian**", Raspberry Pi Operating System is an open-source OS based on the Linux. It is also specifically made to work with different Pi boards. Raspberry Pi OS is made with an ARM processor installed on a number of single-board computers.

Figure 3. Raspberry Pi 4B

Webcam

A webcam is a tiny computer-connected digital video camera. It is sometimes referred to as a web camera that records motion video and takes photographs. To enable real-time video transmission over the Internet, these cameras require the installation of software on the computer. It is capable of taking images and HD films.

Webcams can be standalone devices that are connected to a computer or other device, or they can be integrated into laptops and desktop computers. A webcam is meant to allow for real-time video conversation as well as the audio-visual sharing of ideas and information.

Figure 4. Web Camera

500W Power Inverter

A 500W Power Inverter is very essential on devices that require solar power source. It is a device that converts direct current (DC) electricity, which a solar panel produces, to alternating current (AC) electricity, which the electrical system requires (Luz, 2021).

The main role of a Power Inverter is to regulate the conversion of a Direct Current to an Alternative Current. Furthermore, pumps, relay and other devices can be used to provide a regulated power that can be delivered from the solar system to the device.

Figure 5. 500W Power Inverter

12 and 18 AWG Electrical Wires

According to O' Bryant (2023), electrical wires are metal pieces used to transfer electricity. Electrical AWG Wires are very important to all devices that need electrical input like basic household appliances and other electrical transmission from one point to another. Without wires, electricity would be unavailable to everyone, making them an essential component of modern life. Wires can be of various diameters and compositions depending on their intended use.

There are different types of wire gauge used in the current study and they have their own function in the device. The American Wire Gauge system (AWG) organizes wire gauges, which are different cross-sectional diameters of wires. Knowing the gauge is vital since each is rated for a distinct ampacity, which means that each wire size can carry a maximum electric current before sustaining (potentially serious) damage.

Figure 6. 12 and 18 AWG Electrical Wires

Lead Acid Batteries

All lead-acid batteries consist of two flat plates—a positive plate covered in lead dioxide and a negative plate composed of sponge lead—immersed in an electrolyte pool (a mixture of 35% sulfuric acid and 65% water solution). The chemical reaction that produces voltage also produces electrons. When a circuit is formed between the positive and negative terminals, electricity begins to flow, powering the connected sources.

A lead-acid cell produces voltage by receiving a (forming) charge from a charger of at least 2.1 volts per cell. Lead-acid batteries, often known as storage batteries, do not create voltage itself; rather, they store a charge from another source. The amount of charge that lead-acid batteries can store is determined by the size of their plates and the volume of electrolyte.

The Amp Hour (AH) rating of a battery determines its storage capacity. A common lead-acid battery has a voltage of 2 volts per cell, resulting in a total of 12 volts and a rating of 125 AH. This means the battery can deliver 10 amps of current for 12.5 hours or 20 amps for 6.25 hours. Batteries are constantly charging and discharging, with discharging occurring when connected to a load that requires electricity, such as a car starter and/or an accessory that draws a charge. When current returns to a battery, the chemical difference between the plates is reestablished.

Figure 7. Lead Acid Battery

Solar Panels

Solar Panel is a device that is used in converting a solar power into electricity. Some solar panels also use solar energy to generate heat.

Solar energy harnesses the sun's light and heat to produce renewable or 'green' energy. Solar panels, also known as photovoltaic cells, are the most common way to harness solar energy. They are practically edge-to-edge organized in solar power plants to capture sunlight in huge areas. You'll occasionally see them on top of houses and other structures. Semiconductor materials are used to make the cells. When the sun's rays strike the cells, they dislodge electrons from their atoms. This enables electrons to flow through the cell and produce power.

Figure 8. Solar Panels

Relay Module

With the help of the RPi Relay Board, Raspberry Pi can effortlessly become intelligent by controlling high voltage/high current devices. RPi Relay Board Specifications. The device supports different boards like Raspberry Pi.

It isolates electrical circuits to avoid short circuits and regulate voltage and currents safely. This feature is especially helpful in situations where a microcontroller's tiny control signal must switch greater currents. This control signal is essentially amplified by a relay module, which allows it to handle heavier electrical demands.

Figure 9. Relay Module

A9G GSM Module

A9G GSM device is a standard for facilitation of communication between different electronic devices that facilitates wireless communication between electronic devices via the GSM network. A specialized gadget called a GSM module is the one responsible for the communication of devices via GSM network.

A set of protocols is used by the GSM network, a digital cellular network, to facilitate device-to-device communication. There are base stations in each of the cells that make up the network. It is in charge of creating and preserving the communication channel that connects the device to the network.

This is required for location-based tracking applications like vehicle tracking, asset management, and wildlife monitoring. The module goes beyond that, allowing your Raspberry Pi to send data and messages over cellular networks.

Figure 10. A9G GSM Module

TFT 7-inch Touch Screen

The touchscreen device is easy for anyone to use and was made just for Raspberry Pi. It turns your Raspberry Pi into an easy-to-use touch-controlled system by adding dynamic touch features. This gives one a lot of options for making your projects' features

easy for people to use. The touch screen makes it easier for people to connect with the home automation system, a kiosk, or an educational tool. Users can tap, swipe, and interact directly with apps, menus, and controls. This makes projects easier for people to use and more interesting.

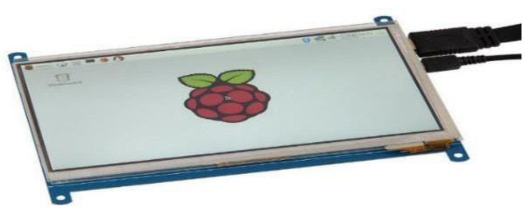


Figure 11. TFT 7-inch Touch Screen

12V DC Water Diaphragm Pump

An electric pump is a versatile component that can be utilized in projects that involve fluid manipulation. Depending on the task, the pump can regulate the flow of gases in experimental setups, dispense precise amounts of fluids for applications such as 3D printing or hydroponics, or circulate liquids for cooling systems. Other applications include precision fluid dispensing. This tool is essential for operations that need precise fluid control. If one utilizes an HDMI to VGA adaptor, the Raspberry Pi will be compatible with older projectors and displays that do not have HDMI connectors. This connector is an important piece of hardware. By converting the Raspberry Pi's HDMI output to a VGA input, one may connect it to a larger range of display devices. This provides him or her with extra connectivity possibilities. This is extremely useful when assembling sets for retro video games, presenting presentations, or working with outdated technology.

Figure 12. 12V DC Water Diaphragm Pump

Charge Controller

It is an important part of different solar power systems. The responsibility of this part is to regulate and balance the flow of current from the panels to batteries or other loads. This keeps the batteries charged properly and stops them from overcharging or deep discharging, both of which can damage them.

Most of the time, charge controls check the batteries' charge level and other necessary information about the solar panel and the battery like voltage. The device can regulate how the batteries and solar panel regulate energy. For example, when the batteries are full, the charging slows down or stops. When they need more power, the charging starts again. This helps the batteries last longer and makes the solar energy system work better and be more reliable overall.

Figure 13. Charge Controller

Linux Operating System

According to Loshin (2023), Linux is a Unix-based operating system (OS) for PCs, servers, mainframes, mobile devices, and embedded systems that is open source and community-developed. It is one of the most commonly used operating systems, supporting nearly every major computer platform, including x86 and many more. The Linux operating system is the stepping stone for the ANDROID platform. An operating system is software the one that is responsible to control hardware resources on users' devices. Simply explained, the operating system oversees the back-and-forth relationship of the hardware and software.

The Linux OS gives commands to the hardware, executes and supports programs, and gives a particular kind of user interface.

Linux has become an effective operating system for hosting websites like Apache, different network administration, scientific computation jobs, management of databases, desktop and endpoint processing, and running mobile devices with various operating systems such as Android.

TensorFlow

According to Yegulalp (2022), machine learning is a hard science, but implementing machine learning models is significantly less difficult than it used to be, thanks to machine learning frameworks like Google's TensorFlow that make obtaining data, training models, serving predictions, and refining future results much easier.

TensorFlow can anticipate production at scale using the same models that were used for training. TensorFlow also comes with a large library of pre- trained models that one can utilize in his or her own applications. One can also utilize TensorFlow Model Garden code as examples of excellent practices while training his or her own models.

It enables developers to design dataflow graphs, which are structures that specify how data moves through a graph or set of processing nodes. Each node in the graph symbolizes a mathematical process, while each link or edge connecting nodes is a tensor, or multidimensional data array.

TensorFlow applications can run on practically any acceptable platform, including a local system, a cloud cluster, iOS and Android devices, CPUs, and GPUs. If people use Google Cloud Platform, users can speed TensorFlow by running it on Google's TensorFlow

Processing Unit (TPU) silicon. TensorFlow-generated models, on the other hand, may be deployed on virtually any device and used to make predictions.

Microsoft LOBE

Lobe is a desktop software program for Windows and Mac that lets anyone create machine-learning models for image classification. Users can design machine learning models with a simple drag-and-drop interface. The steps are simple: gather a data using a camera or saved images, label these images with different categories, train the model, observe the results, and finally run the model. Once completed, the model can be exported to a number of systems. Lobe models can be exported as TensorFlow 1.15 SavedModel, a standard format for Python applications that utilize TensorFlow 1.x and are hosted on AWS, Google Cloud, or Azure. Lobe supports Apple iOS for the development of iOS, iPad, and Mac apps using Core ML, and exports to TensorFlow Lite for the development of Android /Raspberry Pi smartphone and IoT applications. Lobe supports local, spreadsheet, and photo files as well as Phyton languages. Export APIs in NET.

Python

Python is a high-level programming language that is comprehensible. Its high-level built-in data structures, combined with dynamic typing and binding, make it ideal for use as a scripting or glue language to connect existing components Python's succinct, easy-to-learn syntax emphasizes readability, which reduces program maintenance costs. The Python interpreter and extensive standard library are free to use and distribute in source or binary form on all major platforms.

Python is an extremely adaptable programming language. Python is an open-source community language, so many independent programmers are continually adding libraries and features to it. It is capable of processing data, interfacing databases, routing URLs, and maintaining overall security.

Related Studies

This section is an important part of the research journey since it looks deeply into the current body of studies and research that has a direct relevance to the central topic of this inquiry. The researchers travelled the intricate web of academic investigations on these pages, examining, synthesizing, and critiquing the findings, techniques, and contributions of previous studies that have formed the groundwork for the research.

Dispersants as an Oil Spill Clean-Up Technique in the Marine Environment: A Review

According to Nyankson (2022), one of the most fundamental goals of emergency response is to restrict the mobility of the oil as much as possible to prevent it from spreading to surrounding shorelines/habitats as well as reducing the oil's destructive effects on the environment. In general, the approach used to fight the severity of an oil spill is determined by the type of oil spilled (light, medium or heavy), the amount of oil spilled, type of marine life at the spill location, impacted region, environmental circumstances, and time constraints. Considering these variables, the response team has numerous traditional options at its disposal, but a rapid examination is necessary to determine the most appropriate option to totally mitigate the consequences of the spill. Dispersant application is one of the traditional methods available for marine oil spill clean-up exercises. These are the chemical agents used to form small droplets or tiny oil and go beyond the sea water. These numerous tiny oil droplets remain in the water column and disperse naturally with the help of different microbes. The application of dispersants to split oil works because it comprises two types of surfactant molecules: a lipophilic surfactant portion that attracts oil and a hydrophilic portion that is attracted to the water. They align or orient themselves at the oil-water contact and lower oil-water tension. With the current situation, tension is reduced, it causes the oil slick to be rapidly broken up into millions of little droplets. The size of each droplet is very small with lower than 100 microns. With such a small diameter, it means that there is little to no chance that these oil droplets will reappear and generate coalescence. At sea, the mixing of different factors like energy in the form of different natural phenomenon like waves, winds, and currents transfer oil droplets into the water column within a 10-meter radius.

The use of dispersants offers numerous advantages over other methods of oil spill cleanup response strategies for significant spills in the maritime environment. Dispersants can be used to treat a wide range of ailments that includes big offshore spills, subterranean spills, and spills in ice-filled areas environments. Dispersant application is said to be the best response option for Tier III incidents spills at sea because it can operate on even the thinnest slicks, effective in rough seas, and can be added to oil location through various techniques like planes and boats to save some time, the location and magnitude of the spill are irrelevant, and increases spontaneous biodegradation. However, it may be stated that typical approaches suffer from a shortcoming, which is in dealing with oils that have been weathered and emulsified.

In general, the impacts of the dispersant to the marine economy are less scary than the effects of oil being left on the seafloor and go to the shoreline ecosystems which is the worst case scenario. However, there have been numerous studies regarding water dispersants potentially to have a negative effect on biodiversity. Still, it appears that professional discussions on toxicity will continue until a further recommendation is reached on the matter for the time being and in the future of chemical dispersant use. Other issues related to the usage of water dispersants include dispersed solubility and the impact weathering of oil in the marine environment.

A Comparison Study of Clean-Up Techniques for Oil Spills Treatment using Magnetic Nanomaterials

Magnetic nanomaterials have been highlighted as a remediation strategy because they can be used alone, functionalized, or incorporated into various conventional adsorbent materials, as well as being easily removed from the solution after use by applying a magnetic field (Cozzoli et al., 2012; Atta et al., 2014). Gravimetric procedures are absolute and are known for their excellent dependability and precision (Hulanicki, 1995; Richter, 1997). As a standard protocol, several works use the ASTM F726-12 approach. However, the method ignores the amount of water that may be retrieved along with the oil, regardless of whether it is emulsified or pulled between the magnetic particles and the magnet.

As a result of the gravimetric analysis used in the technique, the quantities of water and salt contained in seawater might lead to overestimation. Few studies reported a simple draining step of the magnetic material with the recovered oil (Wu et al., 2014, Jiang et al., 2015; Cojocaru et al., 2017), and only one specified a lyophilization stage before assessing the magnetic material's recovery of the oils (Debs et al., 2019). Most reported studies have ignored this practice, potentially ignoring the contribution of water mass to recovered oil mass (Calcagnile et al., 2012; Grance et al., 2012, Gu & Bernard, 2013; Mao et al., 2014; Elias et al., 2015; Ge et al., 2015, Yu et al., 2015; Pan et al., 2016; Tao et al., 2017). Similarly, the impact of oil API is unexplored and unknown.

Oil spill incident is recovered by magnet based from different nanomaterials employing a magnetic field by a combination of adsorption (lower effect) and propulsion induced by magnetic attraction related with intermolecular interactions between the oil molecules. When employing composite materials loaded with magnetic nanoparticles, removing water prior to gravimetric analysis is crucial for determining oil recovery capabilities correctly.

Bio-based Herding and Gelling Agents from Cholesterol Powders and Suspensions in Organic Liquids for effective Oil Spill Clean-Up

According to the study of Giwa et al. (2022), the efficiency of cholesterol in cleaning crude oil spills was investigated in two forms: solid and suspension. This test was performed to choose the best performing powder and suspension. The solid form is made up of four different powders, and each powder's ability to thicken crude oil slick on the water's surface was investigated. Each cholesterol powder's herder efficacy was assessed using a separate crystallizing dish. The powder with the highest herder efficacy was chosen and utilized to produce suspensions out of all the cholesterol powders evaluated. Other cholesterol powders were eliminated. Suspensions are essential because, when compared to powders, they are easier to administer on oil spill locations utilizing helicopters or other aerially deployed vehicles.

Based on the result of the experiment, the uneven interfacial tension forces between air, water, and crude oil, the crude oil slick spread fast and horizontally over the freshwater surface after being dispensed from a plastic pipette. As a result, the crude oil slick was allowed to spread for 15 minutes to achieve equilibrium. Cholesterol powder forms gelled after herding, whereas suspension forms only herded, except for CP-T, which formed a gel before being utilized for oil spill cleanup. Small particle sizes, anhydrous crystallinity, high purity, and relatively minimal thermal degradation aided the herder effectiveness of cholesterol powders. Using a MATLAB program, the effectiveness of the herder was measured by contracting the surface area of the oil spill. According to the ANOVA results, the herder efficiency of cholesterol-biodiesel suspension was significantly influenced by changes in water salinity and temperature but not by changes in AOR. The agent performed better at low salinity, indicating that the agent needs to be modified/functionalized before it can be employed effectively in saline water conditions. However, at mild or arid temperatures, the agent behaved better. Cholesterol is presented in this study as a new substance for crude oil spill herding and/or gelation (Taher et al., 2022).

Solar-Powered Robots that could Clean Up Oil Spills

According to the study of Zhiwei Li (2021), a new solar-powered robot prototype may be able to clear oil spills in more remote regions in the future, reducing the need for human labor. Researchers from China have developed solar-powered robots that are designed reach isolated ocean places to clean worse oil spill, as described in a recent publication in Science Robotics. The bots can survive in the open ocean for lengthy periods of time because they are hydrophobic and have a high resistance to salt. This development called “Neusbots” are made with high level of knowledge from different fields: "There aren't many ways to achieve this controllable movement using light." "We solved the problem with a tri-layer film that behaves like a steam engine," explained by the owner Zhiwei Li. The bots convert sunlight into heat, which causes water to evaporate, generating the energy required by the robots to make movements. In conclusion, solar light powers the bots, and water fuels their movement.

The researchers' goal was to examine a device that has a feature that could clean oil from previous spills, in addition to increasing its precise mobility.

Skimmer Device for Removal of the Oil Pollution

According to Mohović, M. et al (2022), these devices can be integrated into a static device for oil responses. Each skimmer device gathers oil at a different rate, and the rate of collection is heavily influenced by the type of pump connected to each skimmer.

According to the authors, using pressure pumps move oil to a designated tank. Different pumps are used to move oil from one tank to another. The centrifugal pump is the most utilized pump in unintentional oil contamination. Centrifugal forces cause the oil to flow from the pumping direction to the pressure side. The oil is pushed between the blades of one or more rotors by the radial flow.

Fast response and studying the best equipment and method are very vital to protect the marine environment which can have a substantial influence on flora and fauna. There are different parts of equipment are available to solve pollution from the sea area in the event of accidental oil pollution. The authors investigated a mechanical approach of oil removal utilizing a skimmer equipment. The efficiency of these devices, as well as ancillary equipment including centrifugal and spate pumps, was investigated.

According to the findings of the study, different skimmer devices had varying efficiency when collecting oil from the sea surface. The authors also emphasized the relevance of the pump, stating that the efficiency of each skimmer device is dependent on the pump. The results revealed considerable disparities in the efficiency of skimmer devices when connected to various pumps. In more viscous lubricants, such as bunker fuels used in marine transport of commodities and cargo by sea, almost every pump lost efficiency. In such instances, using a bigger pump hose diameter can greatly improve efficiency. Each new pollutant introduces new obstacles. As a result, it is critical to operate specialized equipment correctly and to be aware of the time required to remove pollutants from the sea surface.

Sensors and Machine Learning for Oil Spill Detection and Monitoring

The remote monitoring with the use of satellite has been widely used in identifying oil spills during the previous years due to its broad coverage, synoptic perspectives, and regularity of obtaining multimodal data. There are numerous review papers in the literature that deal on oil spill RS. This research examined the use and benefits of several sources data of remote sensors and methodologies for oil spill clean-up. Some studies have explored the use of machine learning approaches for detecting oil spills. A wide range of studies have looked at and implemented the synergistic usage of remote sensors and algorithms of machine learning to identify and monitor oil spill slicks.

Electrical Submersible Pump System Model to Assist Oil Lifting Studies

According to Cortes (2019), there are several pieces of equipment for an ESP system to run. The electric motor that powers the ESP system is housed inside the well's production tubing and is connected to the surface facilities via a subsurface power connection. The fluid itself is pumped by means of a multistage centrifugal pump, which is connected to the motor. In this system, the device converts electrical power into mechanical power and transferred to the fluid through a centrifugal pump as pressure. As a result, in order to accurately depict this system, one must comprehend both the mechanical component that limits fluid lifting and the electric power system. The subsea power cable descends from the surface to the motor terminals and passes between the casing and the production tubing. The motor uses the extracted fluid's flow velocity to its advantage to conduct external cooling because it is the deepest ESP component along the pipe. A mechanical seal that shields the engine and keeps the motor oil from becoming contaminated by the production oil connects the motor to the pump. At the pump intake, there is a gas separator located above this seal and prior to the pump. With the least quantity of gas possible, this component enables the well's fluids to enter the pump. To get the fluid to the surface, a multistage centrifugal pump is the last component. The production tubing and the power cable are attached to the wellhead.

The results of the researcher’s testing revealed that the simulations produced appropriate outcomes even with an open-loop U/f control. The use of well-designed filters improved the ESP's performance, underscoring the significance of this technology in this industrial setting. It was also observed that system performance remained largely unaffected even in the event of extreme imbalances in cable impedance. In fact, one may argue that the system is impervious to this issue and therefore Electrical Submersible Pump derating is not necessary.

Synthesis of Related Literature and Studies

According to a research study conducted by Nyankson (2022), dispersant application is one of the traditional methods available for marine oil spill clean-up exercises. These chemical agents are used to the spill to break the thick slicks of oil into quantities of small droplets into the water column. Both the usage of dispersants and the effects of dispersed oil are well recognized. In general, the effects of the dispersant in the water column are less scary than the effects of oil being left on the seafloor to the shoreline ecosystems. There have been numerous studies regarding chemical dispersants potentially having a negative effect on the marine biodiversity. Still, it appears that professional discussions on toxicity will continue until a further recommendation is reached on the matter for the time being and in the future of water dispersant use.

Some researchers studied the use of textile sorbents for oil spill cleanup. According to Zaarour (2023), fiber membranes are regarded as the most important membrane for oil-water separation. Fibers with varied physical and chemical properties can be utilized to build separation membranes with specified specifications. According to the researchers, textiles used in oil-water separation can be divided into three types: Woven Fabric, Knitted Fabric and Nonwoven Fabrics.

Oil Spill is one of the worst problem faced in the marine ecosystem. According to 2019 statistics of ITOPF, different oil transportations has caused approximately 5.86 million tons of oil spills into marine environment from the year 1970 to 2019 with approximately 16,000 tons of oil spilled into oceans in 2010.

As all people know, oil spills have a negative impact on the marine economy and its surroundings. According to different researchers, there is one common goal of research for emergency response and that is to lessen the movement of the oil as much as possible to prevent it from spreading to surrounding shorelines or habitats as well as reducing the oil's destructive effects on the environment. There are several factors that are observed for fighting the severity of an oil spill which are the type of oil spilled, the amount and environmental constraints but a rapid examination and response is necessary to determine and solve the problem. Based on the existing devices and studies, time is one of their major problems. They all have high rate of performing clean-up of oil but other factors like time it takes from the shore to the spill location can have a negative effect. The study that the researchers are currently performing focused on the accuracy and time flexibility of the device. With the use of IoT device, it is much faster to locate, observe and solve the oil spill problem. It is trained to learn the differences of oil to the water for much easier and faster process.

All studies about oil spill solution are very helpful to the marine environment but it also has limitations and issues that need to be addressed. They focused on maximizing existing studies and innovating for better approach. The researchers used dispersant because according to existing studies it has the least issues on the marine economy and its availability. Based on the study of Cholesterol Powders, it is very economic friendly, but the downside is there are only specific circumstances that Cholesterol Powder is effective. Next is the use of Textile Sorbents, there are too many factors that need to study for it to work, it is still a work-in-progress study of knit structure for better oil-water separation. It also has a low-capacity oil sorption than other clean-up solutions. According the existing research of Nyankson, dispersant application is the most appropriate response option for oil incident spills because it can operate on even the thinnest slicks and performs better in rough situations. Also, dispersants have issues that need to be addressed and that is its effects on the marine environment. Numerous discussions are circulating about its deleterious effect on the marine biodiversity. Still, oil spills are more toxic on the marine environment by at least ten times and there are still a lot of research on different kinds of dispersants that can be less harmful in deep-sea environments.

In this study, the researchers used a specific kind of dispersant which is water- based, it is more economic friendly to the marine environment than regular chemical dispersants. Through the years, there are a lot of dispersants developed to have less negative impact in the environment. The specific objective is to develop a device that can help to minimize the oil spill effect on human health and offshore ecosystems. Also, the main objective of the current study is to develop a device that can answer the problem on the fastest way possible and that is the use of machine learning.

Conceptual Model of the Study

The conceptual model of the study is summarized in Figure 14, it presents the Input-Process-Output (IPO) framework, which also provides a framework for conceptualizing the project's components and serves as a guide for the development of the system.

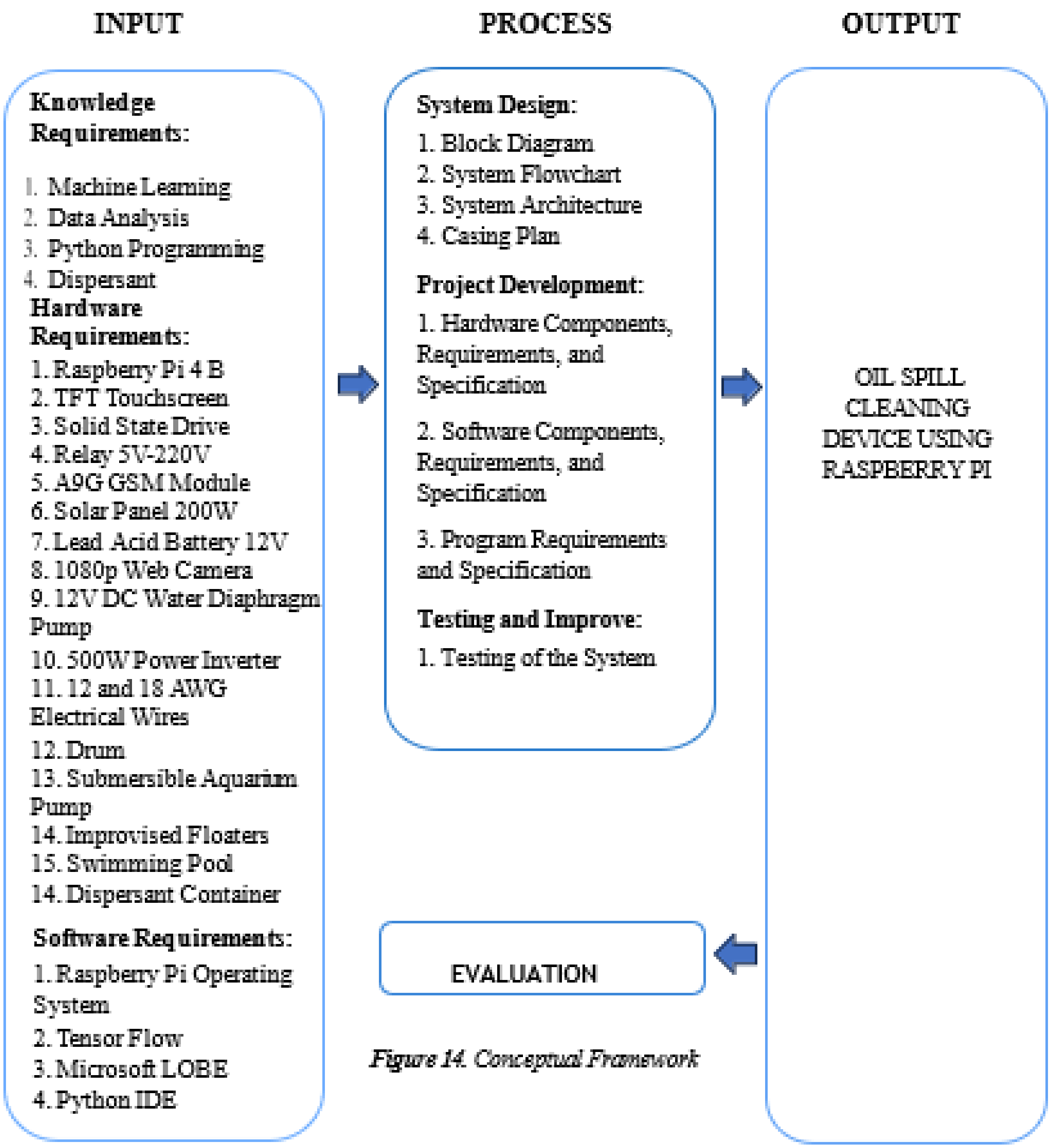


Figure 14. Conceptual Framework

Input

The input requirements are organized into three categories such as: knowledge requirements, software requirements, and hardware requirements.

The knowledge requirements are the following: Machine Learning, Data Analysis, Python Programming, and Dispersant.

The hardware requirements include the system's physical parts, such as the Raspberry Pi 4 B, TFT Touchscreen, Solid State Drive, Relay, A9G GSM Module, Solar Panel, Lead Acid Battery, 1080p Web Camera, 12V DC Water Diaphragm Pump, 500W Power Inverter, Drum, Submersible Aquarium Pump, Improvised Floaters, Swimming Pool, 12 and 18 Electrical Wires and Dispersant Container. These elements were primarily used in the system's development.

The non-physical parts of the system, such as the Linux Operating System, Tensor Flow, Microsoft LOBE, Arduino IDE, and Python IDE, are all contained in the necessary software requirements. They are all instructions, information, or software required to run the system.

Process

The concept model of this research divides the process into four stages:

1. Included in system design are block diagram, system flowchart, system architecture, and casing plan.

2. System developmentrepresents hardware development and programming

3. Project development represents the requirements and specification of hardware components, software components, and programs.
4. The testing procedure includes testing of the system.

The project needs to be evaluated using the TUP evaluation tool for the prototype created.

Output

The Smart Oil Saver (SOS): An Arm Based Oil Spill Cleaning Device using Machine Learning has been created by combining the knowledge, software, and hardware requirements through the project design, development, and testing and evaluation.

Operational Definition of Terms

The following terminologies are defined for a better understanding in the context of the study:

Automation refers to the device's ability to work independently, such as navigating to oil spill spots and initiating cleanup without constant user participation.

Anomaly Detection refers to finding unusual patterns or behaviors in sensor data or image feeds that could point to the existence of an oil.

Alerts and Notifications refers to the system's ability to deliver warnings and notifications to users in the event of crucial instances or when maintenance is required.

Data Integration refers to the integration of data from various sensors and sources, such as cameras, GPS, and environmental sensors, to provide a full view of the oil spill scenario and aid in decision-making.

Data Logging refers to the process of gathering and storing data about the device's activities, oil spill cleanup statistics, and other relevant information.

Deployment refers to the integration of trained models into the operational environment to enable real-time monitoring and decision making.

Image classification refers to the process of categorizing images captured by the device into different classes, such as oil, water, debris, and so on, using machine learning algorithms.

Model Training refers to the process of training models on historical data using machine learning algorithms to better understand patterns and relationships.

Remote Monitoring refers to the ability to view real-time data and device status through the mobile application, allowing users to make informed decisions and make necessary adjustments.

Resource Allocation refers to optimizing how and when to allocate resources, such as the oil dispersant, based on a real-time assessment of the impact of the oil spill and the surrounding environment.

Wireless Communication refers to the process which the Raspberry Pi communicates with the user using cellular network.

Smart Filtering refers to using machine learning algorithms to detect and eliminate noise and unnecessary data from sensor readings or image feeds in order to increase the accuracy of oil spill detection for efficient cleanup operations.

Chapter 3

METHODOLOGY

In this chapter, the different methods employed by the researchers for the project “Smart Oil Saver (SOS): Arm-based Oil Spill Cleaning Device using Machine” learning operation, testing, and assessment processes are covered.

Project Design

The following figures depict the block diagram and flowchart. The project titled "Smart Oil Saver (SOS): Arm-based Oil Spill Cleaning Device using Machine Learning" was developed. This will facilitate the demonstration and elaboration of the plan's design, thereby providing guidance to the researchers in the development and operation of the prototype device.

Block Diagram

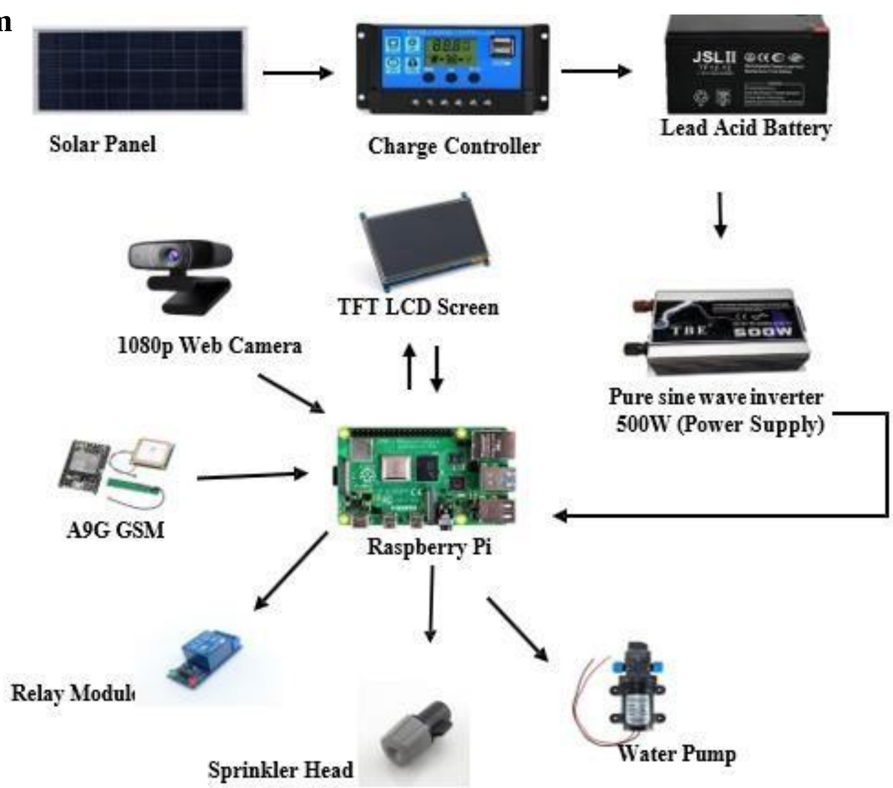


Figure 15. Block Diagram

The illustration in Figure 15 shows the process of Smart Oil Saver (SOS): An Arm-Based Oil Spill Cleaning Device using Machine Learning. This block diagram illustrates the interconnected components of the oil spill cleaning device and showcasing how each contributes to the overall functionality of the system. The Raspberry pi 4b serves as the processing unit of the system for functionality and control. In order to provide the necessary power for this device, the diagram illustrates the utilization of a 200-watt solar panel for the purpose of harnessing sunlight. The charge controller is responsible for overseeing and regulating the entire process, ensuring the battery's protection. The Lead Acid Battery is employed to store the solar energy acquired during this process. The lead acid battery's DC power is converted into AC power using a pure sine wave inverter. This stable source of AC power is needed for supplying power to the Raspberry Pi and other devices connected to the system. The stored energy is harnessed by the Raspberry Pi to power various devices that are connected to it, such as the TFT LCD screen. This screen is responsible for displaying information, including the results of machine learning analysis and other system updates. In order to facilitate visual examination of the oil spill, researchers employed an 1080p web camera. Additionally, once there is a substance detected the researchers use a a9g GSM module to enable the connectivity of the system. It communicates with the user via cellular networks, allowing for remote monitoring and control. On the other hand, the relay acts as a switch for the pump and the water pump is responsible for the task of deploying oil dispersant.

Flowchart

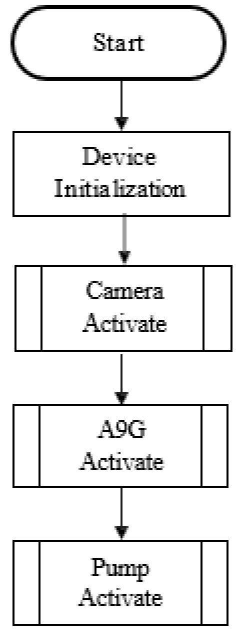


Figure 16. Flowchart of the Smart Oil Saver (SOS)

In Figure 16, a flowchart was used in illustrating the process flow of the prototype oil spill cleaning device. The device will be activated and initialized, then the camera, a9g GSM, and the pump will be activated.

Camera Activation

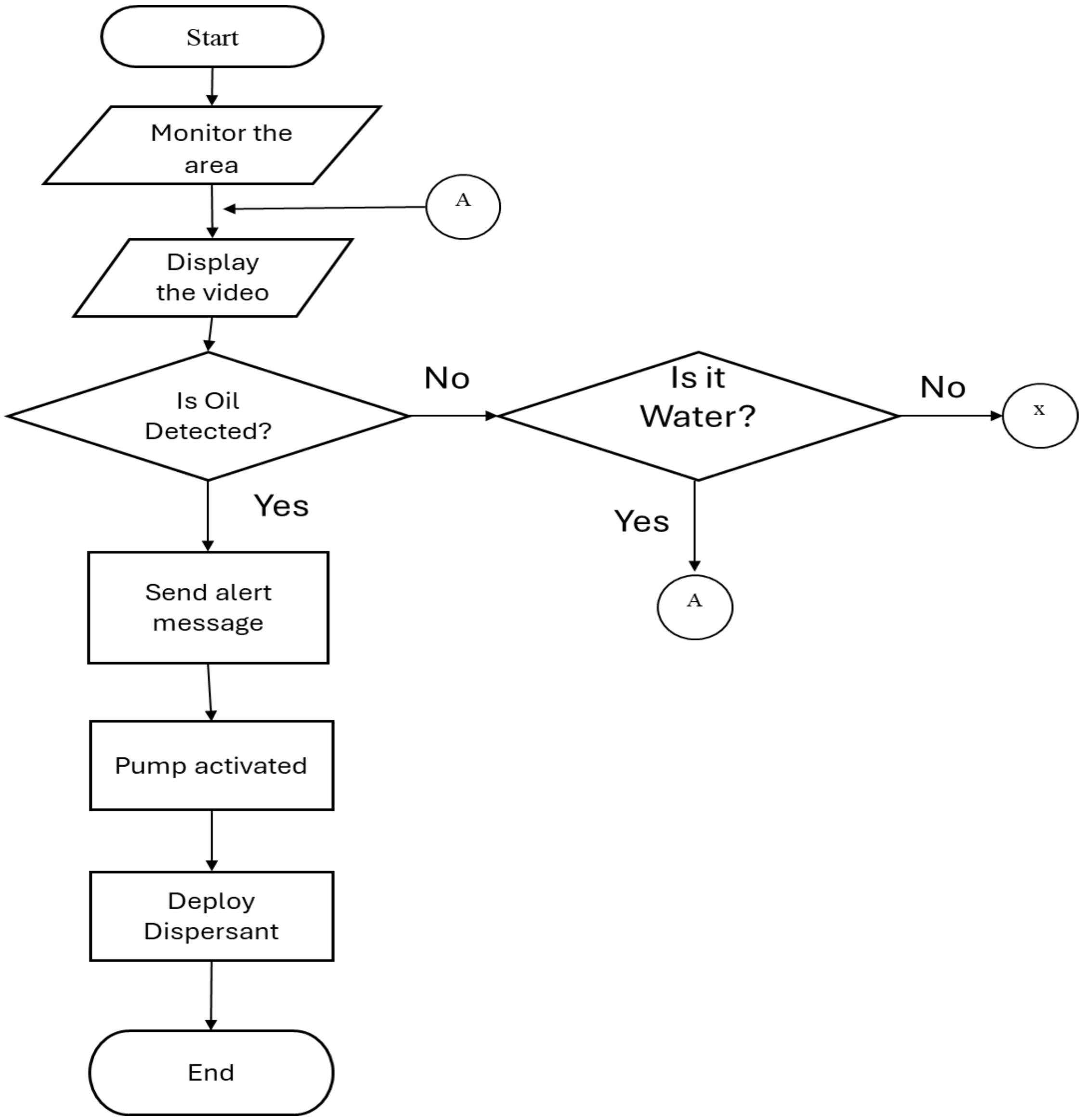


Figure 17. Flowchart of Camera Activation on Smart Oil Saver (SOS)

In Figure 17, the camera will be activated to monitor the area for oil spill detection. The video stream will be displayed. If oil is detected, it will send the alert message to the user. The pump will be activated to deploy dispersant to the area. If water is detected, the process continues in monitoring the area until oil is detected.

A9G Activation

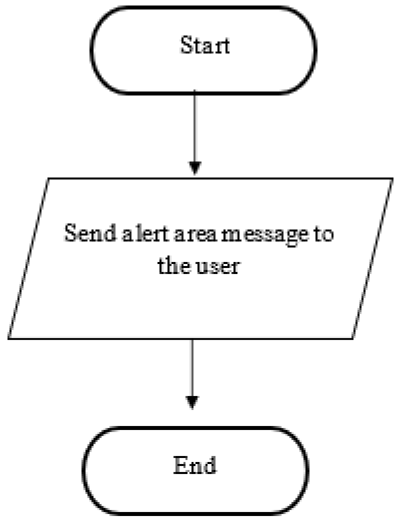


Figure 18. Flowchart of A9G Activation on Smart Oil Saver (SOS)

Figure 18 shows the process of the activation of A9G GSM. The user will be able to get the alert area message of the prototype device

Hardware Architecture

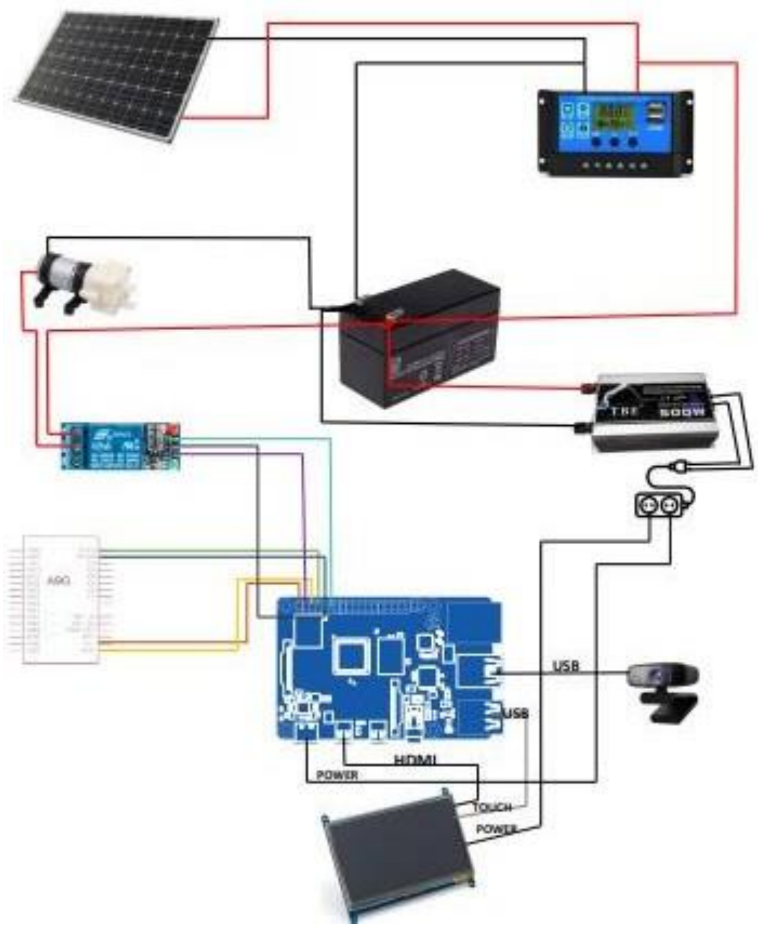
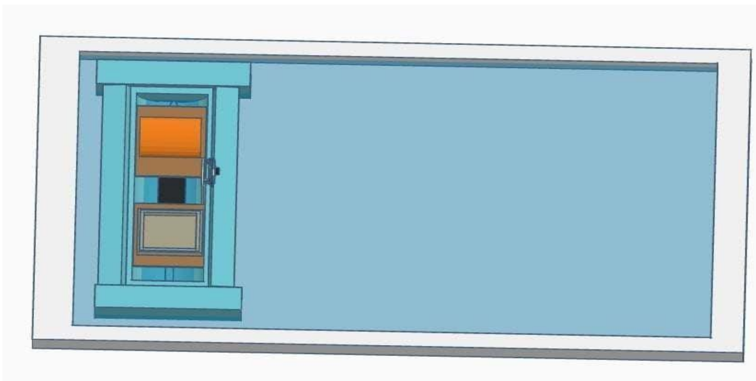


Figure 19. Hardware Architecture of Smart Oil Saver (SOS)

Figure 19 illustrates the Hardware Architecture of the device. It shows the interconnected components of oil spill cleaning device and how each contributes to the overall functionality of the system. Solar panel's purpose to collect sunlight. A charge controller manages electrical power and stores it in a battery. The Raspberry Pi, the brain of the system, uses the stored energy to power itself and other devices. A camera processes images of the oil spill, and a GSM module enables remote communication over cellular networks. When the Raspberry Pi detects oil via the camera, it triggers a relay, which activates a water pump and releases oil dispersant. An TFT LCD screen is responsible to display information regarding the system's operation.

Casing Plan



Top View

Front View

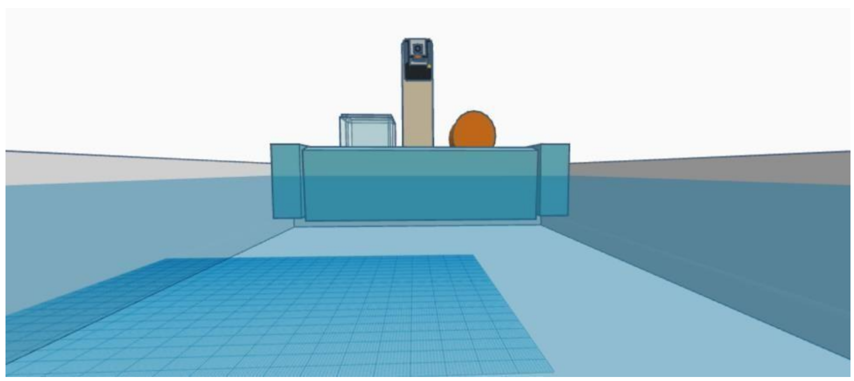


Figure 20. Casing Plan

Project Development

The project development encompassed a systematic approach to constructing the prototype, proceeding through each phase of the production process. The project prototype utilized the processes outlined in the following procedures.

Hardware Components

1. Measured the desired size of the container for an Arm-based oil spill cleaning device.
2. The required hardware components for constructing the prototype system were carefully assembled and eventually went through detailed testing.
    - 2.1 Raspberry Pi 4 B
    - 2.2 TFT Touchscreen
    - 2.3 Solid State Drive
    - 2.4 Relay 5V-220V
    - 2.5 A9G GSM Module
    - 2.6 Solar Panel 200W
    - 2.7 Lead Acid Battery 12V
    - 2.8 1080p Web Camera
    - 2.9 12V DC Water Diaphragm Pump
    - 2.10 500W Power Inverter
    - 2.11 12 and 18 AWG Electrical Wires
    - 2.12 Drum
    - 2.13 Submersible Aquarium Pump
    - 2.14 Improvised Floaters
    - 2.15 Swimming Pool

3. Organized the project’s components.

3.1 A schematic and circuit design have been created to function as a point of reference for the connection of various hardware components.

4. Assembled all the components of hardware.

4.1 Attached the Arm-based oil spill cleaning prototype’s Raspberry Pi, actuators, and sensors.

4.2 Assembled and soldered all the wires that establish connections between the different components.

5. Conducted thorough testing on the entire prototype system.

Software Components

1. Planned and designed the system flow of Smart Oil Saver

2. Installed TensorFlow, and Microsoft LOBE.

3. Installed the Raspberry Pi emulator in TFT LCD display.

4. Tested the system program.

Operation and Testing Procedure

The operation and testing procedure of the Smart Oil Saver: An ARM-based Oil Spill Cleaning Device using Machine Learning were performed to test its identity and functionalities.

The following procedures on how to operate the device were undertaken:

1. Connected the Solar Panel to the Lead Acid Battery, Charge Controller and Power Inverter.
2. Started the device by turning on the Power Inverter,
3. Internet or data is required for users.
4. Ran the program that will activate the camera for detection.
5. The device will send an alert message to the user.
6. Once detected, dispersant will be deployed.

Table 16

Hardware Test Case Raspberry Pi

TEST CASE NAME	STEPS/ACTIONS	EXPECTED OUTPUT
Check the connection and functions of the Raspberry Pi.	Connect the Raspberry Pi to the device and verify if the Power LED on the Raspberry Pi is lighting up.	The Command Line-Interface (CLI) is responsive.
	Make sure that all necessary cables are connected. Test the functions of all the GPIO pins by connecting to	The Raspberry Pi responds the programs indicated.

	an external device and try to run commands or libraries.	

Table 17

Hardware Test Case for Power System

TEST CASE NAME	STEPS/ACTIONS	EXPECTED OUTPUT
Check the connection of Solar Panel to the Charge Controller	Mount the cables of Solar Panel to the Charge Controller.	The Charge Controller presents the voltage input and output of Solar Panel.
Check the connection of Lead Acid Battery to the Charge Controller	Mount the cables of Lead Acid Battery to the Charge Controller.	The Charge Controller presents the voltage input and output of Lead Acid Battery. It will automatically charge the battery from the power of Solar Panel.

Check the connection of Lead Acid Battery to the Power Inverter	Mount the positive and negative cables of the battery to the Power Inverter.	When the switch of Power Inverter is turned on, it will automatically generate power connected to the Raspberry Pi.

Table 18.

Test Case for Oil Detection and Clean-up

TEST CASE NAME	STEPS/ACTIONS	EXPECTED OUTPUT
Checking the functionality of the webcam.	Connect the webcam to the Raspberry Pi and run the program.	The device will automatically detect the area with oil.
Checking the functionality of the A9G Module.	Connect the A9G Module to the Raspberry Pi and Relay Module	After the oil is detected, it will automatically send SMS message to the user.
Checking the functionality of the pump.	Connect the Submersible Pump to the Lead Acid Battery and Relay Module.	The device will automatically deploy dispersants.

Evaluation Procedure

To determine the level of acceptability of the prototype device, the researchers used the Technological University of the Philippines (TUP) evaluation instrument for prototype developed. The prototype device was assessed by the Engineers, Architects, IT Professionals and Philippine Coast Guard (PCG). The evaluation methods were conducted in the following way:

1. The respondents were provided with an explanation of the prototype device functionality by the researchers. The researchers responded to the respondents' queries by providing a video demonstration of the testing procedure along with a description of the features, functions, and goals.
2. A 4-point Likert Scale was used to rate the prototype, with the criteria of functionality, compatibility, efficiency, performance efficiency, usability, reliability, and maintainability.

Scale	**Descriptive Rating**
4	Highly Acceptable
3	Very Acceptable
2	Fairly Acceptable
1	Not Acceptable

CHAPTER 4

RESULTS AND DISCUSSION

This chapter contains an overview of the project, including its description, structure, capabilities, and limitations. The project evaluation that is presented in this chapter determined the effectiveness of the developed system. This enables the researchers to evaluate potential improvements for the developed prototype device.

Project Description

The Smart Oil Saver is prototype device has been developed to address the problem of oil spill through detection and cleaning up oil spills. This detailed system integrates cutting-edge technologies such as Machine Learning algorithms, and sensors. Through the implementation of Smart Oil Saver, the innovative approach helped to achieved more effective detection and cleaning up of oil, contributing to a solution for environmental conservation by mitigating the damage caused by incidents.

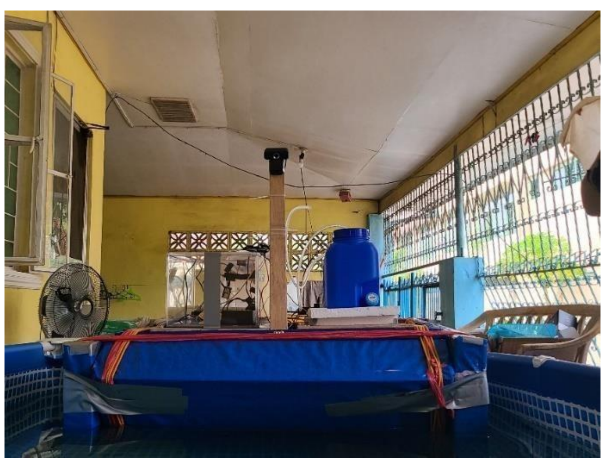


Figure 21. Actual Prototype Device of the Smart Oil Saver

Figure 21 illustrates the actual prototype of Smart Oil Saver along with the installation of the devices and sensors in a large blue container with improvised floaters.

Project Structure

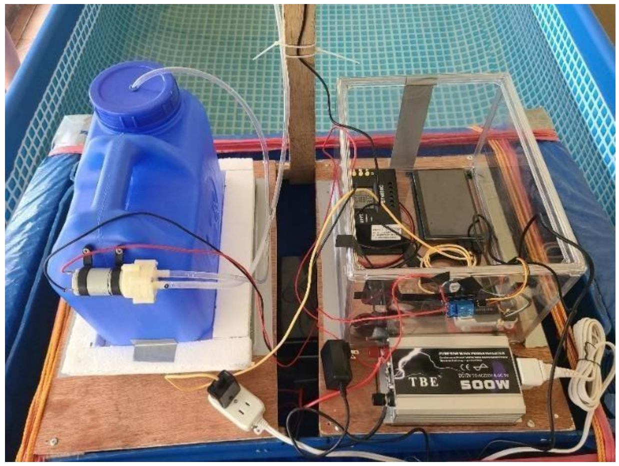


Figure 22. Smart Oil Saver Back Model View

Figure 22 depicts the interconnection of the various components of the smart oil saver, including the Raspberry Pi, touchscreen, Webcam, GSM, and the relay that is connected to the 12v pump. Battery, charge controller, and inverter. The Raspberry Pi serves as the brain of the device and it coordinates various functions such as utilizing the touchscreen as a user interface to display real-time data and controls, while the webcam captures visuals of the oil spill for monitoring. When an oil spill is detected, the Raspberry Pi uses GSM to communicate with users, and a relay connected to it controls the 12V pump, which disperses the dispersant. Also, the charge controller simplifies the connection of the solar panel to the battery, regulating energy flow, with the solar panel serving as the primary power source managed by the charge controller. The battery stores solar energy, providing power when the primary source is unavailable or in low-light conditions. Furthermore, an inverter connected to the battery converts DC power to AC power, allowing the Raspberry Pi and other devices to operate more efficiently.

Project Capabilities and Limitations

The following are the capabilities of the developed systems:

1. Camera Detection: Visual Detection of Oil Spill becomes easier as the researchers used high resolution camera together with machine learning that helped in the automated detection of oil spill.
2. SMS Notification: Through GSM module, it enables real-time data transmission via SMS notification when oil spill is detected, this can be an alert system to make sure that it notifies right away in order to immediately know if there is oil detected.
3. Dispersant Deployment: When oil is detected, the relay turns on the pump to deploy dispersants. The device automatically releases an oil dispersant that is stored.

The following are the limitations of the developed system.

1. Distance Limitations: The distance that the camera can be detected has a certain range, which would lessen its capacity to detect oil far from its position.
2. Machine Learning Algorithms: The system uses image recognition and data analysis, but it may encounter errors if the data are not registered, making it unable to identify the substance.
3. Response Time: The speed of detecting an oil spill may be delayed due to the time required for data processing and the device's limited processing power or memory, which slows down the execution of the device.

4. Data records: The device does not have database and an IoT platform for real-time data transmission, storage, and management, so it cannot store data such as recorded videos. As a result, data monitoring and accessing recorded data are not possible.
5. Message Loss: SMS messages may be lost or delayed without notification, particularly in instances of network outages or disruption.

Project Evaluation

The study was assessed by a group consisting of 15 IT Professionals, 7 Engineers and Architect, and 8 members of the Philippine Coast Guards. This process was conducted to assess the acceptability and quality of the system in terms of its efficiency and research goals.

Functionality

The Functionality criterion has four indicators to be answered: 1) Accuracy in oil detection, 2) Speed of the detection procedure, 3) The range and width of the camera to detect oil, and 4) The ability to distinguish between oil and water. There was a total of 30 respondents who were able to take part and answer the evaluation form. Every participant was assigned a number ranging from 1 to 30. The evaluation utilized a rating scale ranging from 1 to 4, where a rating of 4 represents the highest rating, and 1 the lowest rating. Figure 23 illustrates a graphical representation of the responses. The bars represent each of the acceptance levels, where the blue bar corresponds to the rating of Highly Acceptable, the orange bar corresponds to a rating of Very Acceptable, the yellow bar corresponds to Fairly Acceptable, and the green bar corresponds to Not Acceptable. The weighted mean for the

Functionality criterion was calculated as 3.52 (Very Acceptable).

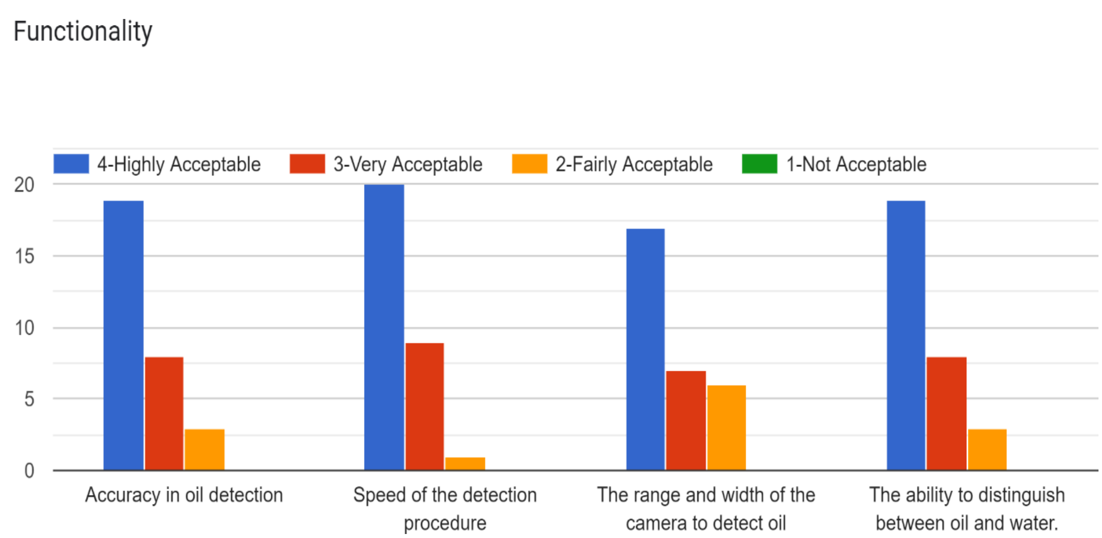
Table 19

Evaluation Result and Weighted Mean Computation for Functionality

RESPONDENTS	Question 1	Question 2	Question 3	Question 4	Weighted Mean
Respondent 1	4	3	3	3	3.25
Respondent 2	4	4	4	4	4.00
Respondent 3	3	4	3	3	3.25
Respondent 4	4	4	4	4	4.00
Respondent 5	3	3	2	3	2.75
Respondent 6	4	4	4	4	4.00
Respondent 7	4	4	4	4	4.00
Respondent 8	4	4	4	4	4.00
Respondent 9	3	4	4	4	3.75
Respondent 10	4	4	3	4	3.75
Respondent 11	3	4	4	4	3.75
Respondent 12	4	4	3	4	3.75

Respondent 13	4	4	4	4	4.00
Respondent 14	4	4	4	4	4.00
Respondent 15	4	3	4	3	3.50
Respondent 16	4	4	4	4	4.00
Respondent 17	3	3	4	3	3.25
Respondent 18	4	4	4	4	4.00
Respondent 19	2	2	2	2	2.00
Respondent 20	4	3	3	4	3.50
Respondent 21	3	4	2	3	3.00
Respondent 22	2	3	2	2	2.25
Respondent 23	2	3	2	2	2.25
Respondent 24	3	3	3	3	3.00
Respondent 25	3	3	2	3	2.75
Respondent 26	4	4	3	4	3.75
Respondent 27	4	4	4	4	4.00

Respondent 28	4	4	4	4	4.00
Respondent 29	4	4	4	4	4.00
Respondent 30	4	4	4	4	4.00
Overall Weighted Mean	3.53	3.63	3.37	3.53	3.52



Evaluation for Functionality Criterion

Figure 23. Evaluation Result for Functionality

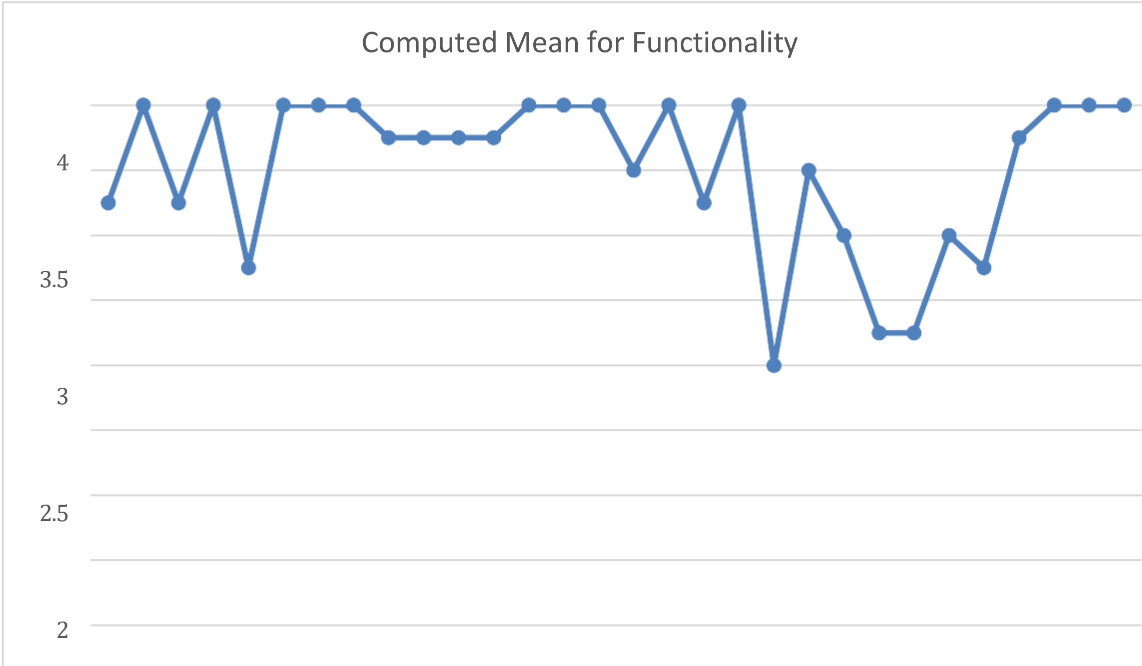


Figure 24. Computed Weighted Mean for Functionality

Compatibility

The Compatibility criterion has one indicator to be answered: 1) Integration with other platforms or systems. There was a total of 30 respondents who were able to take part and answer the evaluation form. Every participant was assigned a number ranging from 1 to 30. The evaluation utilized a rating scale ranging from 1 to 4, where a rating of 4 represents the highest rating, and 1 the lowest rating. Figure 25 illustrates a graphical representation of the responses. The bars represent each of the acceptance levels, where the blue bar corresponds to a rating of Highly Acceptable, the orange bar corresponds to Very Acceptable, the yellow bar corresponds to Fairly Acceptable, and the green bar corresponds to Not Acceptable. The weighted mean for the Compatibility criterion was calculated as 3.67 (Highly Acceptable).

Table 20

Evaluation Result and Weighted Mean Computation for Compatibility

RESPONDENTS	Question 1	Weighted Mean
Respondent 1	4	4.00
Respondent 2	4	4.00
Respondent 3	4	4.00
Respondent 4	4	4.00
Respondent 5	4	4.00
Respondent 6	4	4.00
Respondent 7	4	4.00
Respondent 8	4	4.00
Respondent 9	4	4.00
Respondent 10	4	4.00
Respondent 11	4	4.00
Respondent 12	4	4.00
Respondent 13	4	4.00

Respondent 14	4	4.00
Respondent 15	4	4.00
Respondent 16	4	4.00
Respondent 17	4	4.00
Respondent 18	3	3.00
Respondent 19	4	4.00
Respondent 20	2	2.00
Respondent 21	4	4.00
Respondent 22	3	3.00
Respondent 23	3	3.00
Respondent 24	2	2.00
Respondent 25	3	3.00
Respondent 26	3	3.00
Respondent 27	2	2.00
Respondent 28	3	3.00
Respondent 29	3	3.00

Respondent 30	3	3.00
Overall Weighted Mean	**3.67**	**3.67**

Compatibility

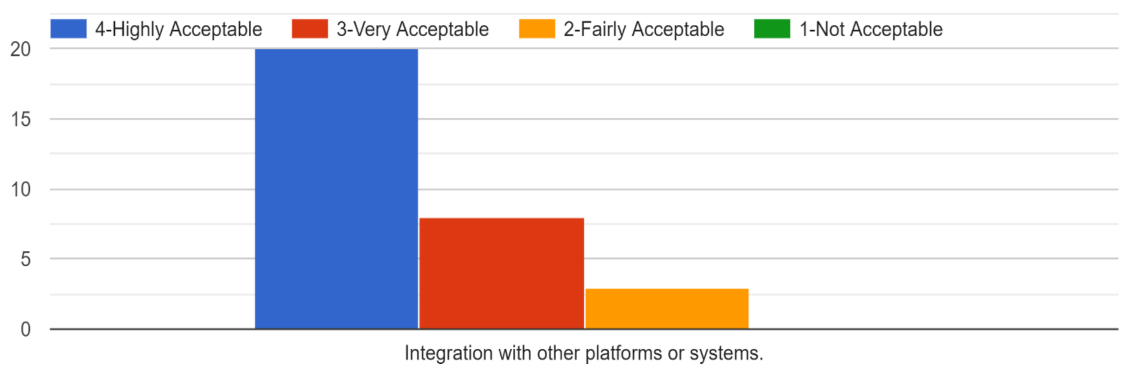


Figure 25. Evaluation Result for Compatibility

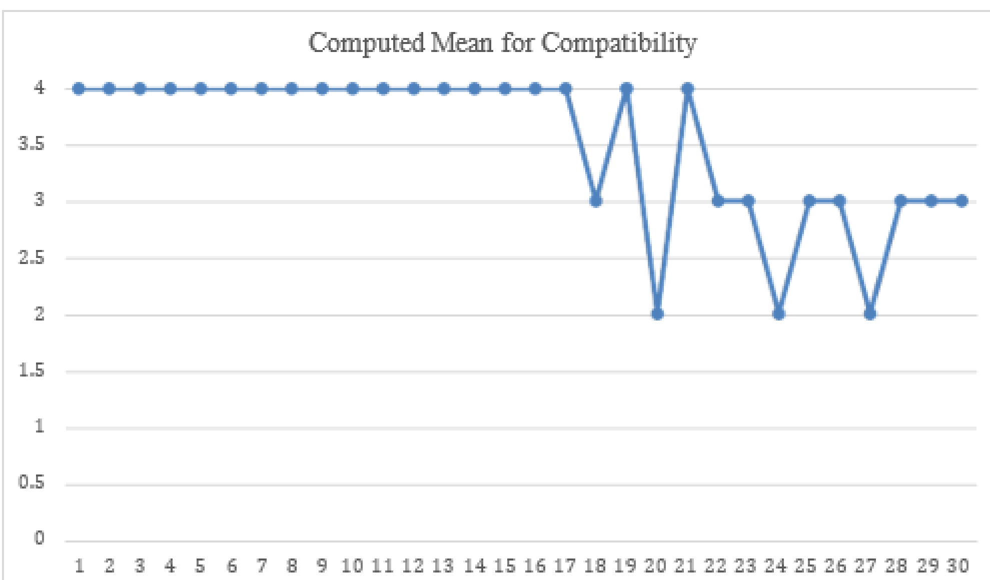


Figure 26. Computed Weighted Mean for Compatibility

Efficiency

The Efficiency criterion has three indicators to be answered: 1) The processing speed of machine learning algorithms, 2) Scalability to handle huge amounts of data, and

3) Minimization of having false positives or negatives. There was a total of 30 respondents who were able to take part and answer the evaluation. Every participant was assigned a number ranging from 1 to 30. The evaluation utilized a rating scale ranging from 1 to 4, where a rating of 4 represents the highest rating, and 1 the lowest rating. Figure 27 illustrates a graphical representation of the responses. The bars represent each of the acceptance levels, where the blue bar corresponds to a rating of Highly Acceptable, the orange bar corresponds to Very Acceptable, the yellow bar corresponds to Fairly Acceptable, and the green bar corresponds to Not Acceptable. The weighted mean for the Compatibility criterion was calculated as 3.44 (Very Acceptable).

Table 21.

Evaluation Result and Weighted Mean Computation for Efficiency

RESPONDENTS	Question 1	Question 2	Question 3	Weighted Mean
Respondent 1	4	4	4	4.00
Respondent 2	3	4	4	3.67
Respondent 3	3	3	4	3.33

Respondent 4	4	4	3	3.67
Respondent 5	4	4	3	3.67
Respondent 6	4	4	4	4.00
Respondent 7	4	4	4	4.00
Respondent 8	4	4	4	4.00
Respondent 9	3	4	3	3.33
Respondent 10	4	4	3	3.67
Respondent 11	4	2	4	3.33
Respondent 12	4	4	4	4.00
Respondent 13	4	4	3	3.67
Respondent 14	4	4	4	4.00
Respondent 15	4	4	4	4.00
Respondent 16	4	3	4	3.67
Respondent 17	4	4	4	4.00
Respondent 18	3	3	4	3.33
Respondent 19	4	4	3	3.67

Respondent 20	2	2	3	2.33
Respondent 21	4	3	4	3.67
Respondent 22	3	4	4	3.67
Respondent 23	2	3	2	2.33
Respondent 24	2	3	2	2.33
Respondent 25	3	2	2	2.33
Respondent 26	3	2	2	2.33
Respondent 27	4	4	4	4.00
Respondent 28	3	4	4	3.67
Respondent 29	3	4	2	3.00
Respondent 30	3	3	2	2.67
Overall Weighted Mean	**3.47**	**3.5**	**3.37**	**3.44**

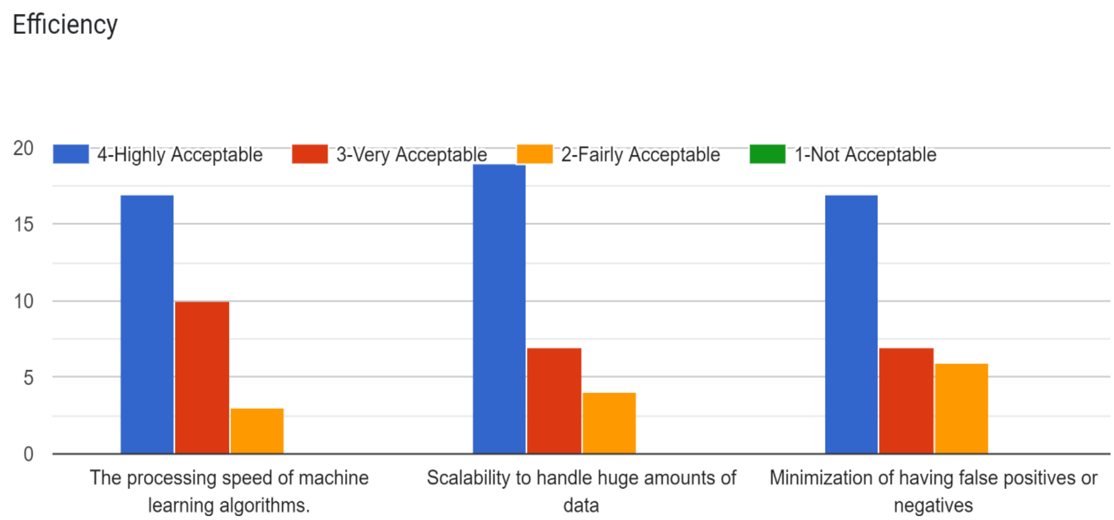


Figure 27. Evaluation Result for Efficiency

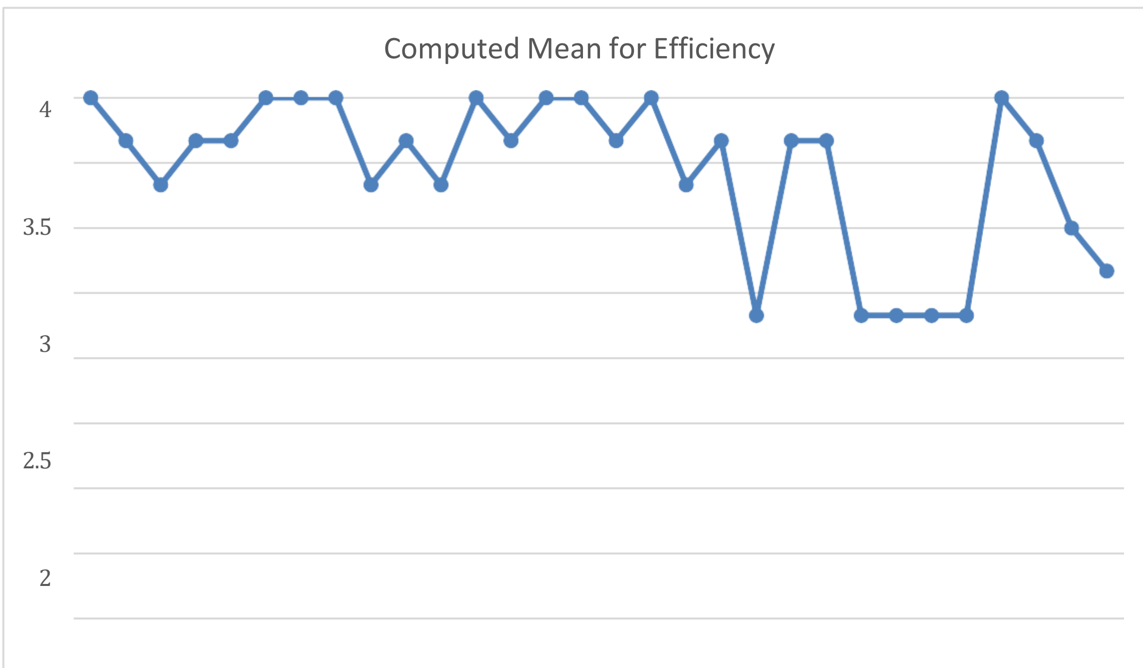


Figure 28. Computed Weighted Mean for Efficiency

Performance Efficiency

The Performance Efficiency criteria has four indicators to be answered: 1) Consistent detection of oil over time, 2) The response time to changes in oil, 3) Capable of handling multiple detection tasks simultaneously, and 4) Minimization of error or inaccuracies in detection results. There was a total of 30 respondents who were able to take part and answer the evaluation. Every participant was assigned a number ranging from 1 to 30. The evaluation utilized a rating scale ranging from 1 to 4, where a rating of 4 represents the highest rating, and 1 the lowest rating. Figure 29 illustrates a graphical representation of the responses. The bars represent each of the acceptance levels, where the blue bar corresponds to a rating Highly Acceptable, the orange bar corresponds as Very Acceptable, the yellow bar corresponds as Fairly Acceptable, and the green bar corresponds to Not Acceptable. The weighted mean for the Compatibility criteria was calculated as 3.42 (Very Acceptable).

Table 22.

Evaluation Results and Weighted Mean Computation for Performance Efficiency

RESPONDENTS	Question 1	Question 2	Question 3	Question 4	Weighted Mean
Respondent 1	4	4	4	4	4.00
Respondent 2	4	4	4	4	4.00
Respondent 3	3	3	4	4	3.50
Respondent 4	4	4	4	4	4.00
Respondent 5	4	4	4	3	3.75
Respondent 6	4	4	4	4	4.00

Respondent 7	4	4	4	4	4.00
Respondent 8	4	4	4	4	4.00
Respondent 9	3	4	3	2	3.00
Respondent 10	4	4	3	4	3.75
Respondent 11	1	1	1	1	1.00
Respondent 12	4	4	4	4	4.00
Respondent 13	4	4	4	3	3.75
Respondent 14	4	4	4	4	4.00
Respondent 15	4	4	4	4	4.00
Respondent 16	4	3	4	4	3.75
Respondent 17	4	4	4	4	4.00
Respondent 18	3	3	4	2	3.00
Respondent 19	4	4	3	3	3.50
Respondent 20	2	3	3	2	2.50
Respondent 21	4	3	4	2	3.25
Respondent 22	3	4	4	3	3.50

Respondent 23	2	3	2	3	2.50
Respondent 24	3	3	2	3	2.75
Respondent 25	3	2	2	3	2.50
Respondent 26	3	2	3	4	3.00
Respondent 27	4	3	4	4	3.75
Respondent 28	3	4	4	3	3.50
Respondent 29	4	3	2	3	3.00
Respondent 30	4	3	3	3	3.25
Overall Weighted Mean	**3.5**	**3.43**	**3.43**	**3.3**	**3.42**

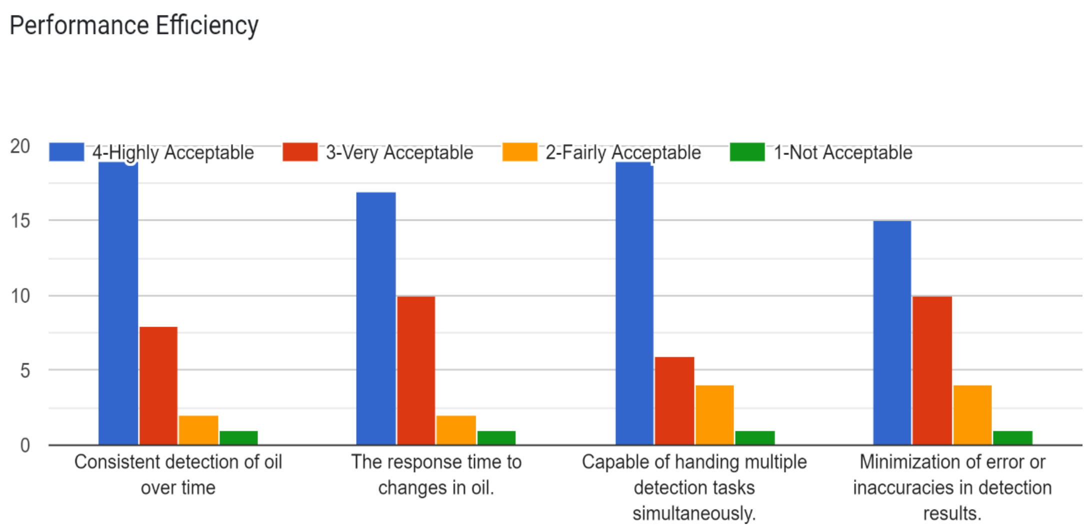


Figure 29. Evaluation Result for Performance Efficiency

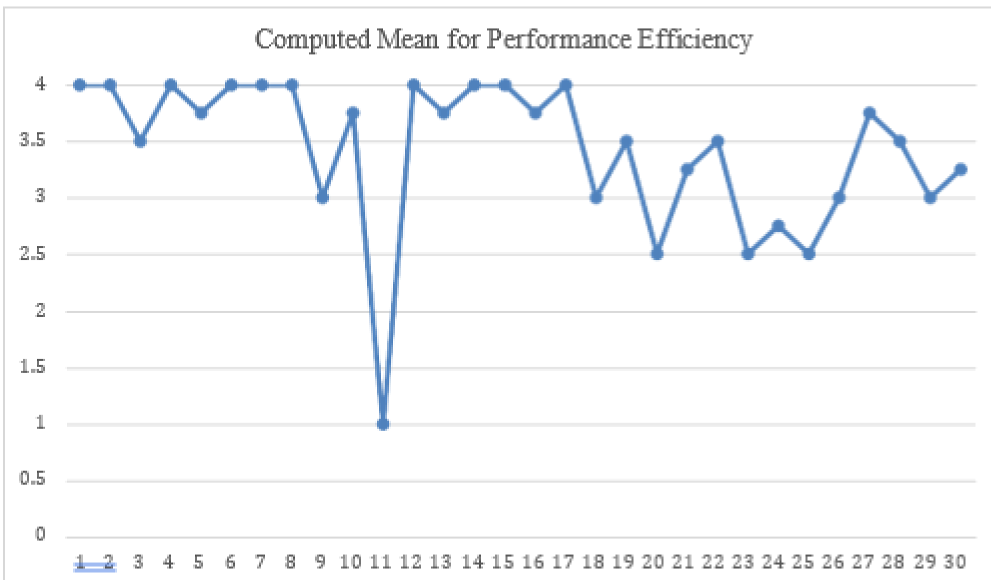


Figure 30. Computed Weighted Mean for Performance Efficiency

Usability

The Usability criteria has three indicators to be answered: 1) Availability of data and analysis results, 2) Easy to maintain and troubleshoot, and 3) Customization options based on user preferences or specific requirements. There was a total of 30 respondents who were able to take part and answer the evaluation. Every participant was assigned a number ranging from 1 to 30. The evaluation utilized a rating scale ranging from 1 to 4, where a rating of 4 represents the highest rating, and 1 the lowest rating. Figure 31 illustrates a graphical representation of the responses. The bars represent each of the acceptance levels, where the blue bar corresponds to a rating of Highly Acceptable, the orange bar corresponds to Very Acceptable, the yellow bar corresponds to Fairly Acceptable, and the green bar corresponds to Not Acceptable. The weighted mean for the Compatibility criteria was calculated as 3.44 (Very Acceptable).

Table 23.

Evaluation Results and Weighted Mean Computation for Usability

RESPONDENTS	Question 1	Question 2	Question 3	Weighted Mean
Respondent 1	4	4	4	4.00
Respondent 2	3	4	4	3.67
Respondent 3	3	3	4	3.33
Respondent 4	4	4	2	3.33
Respondent 5	3	4	2	3.00
Respondent 6	3	4	4	3.67
Respondent 7	2	4	4	3.33
Respondent 8	4	4	4	3.00

Respondent 9	3	4	4	3.67
Respondent 10	4	4	4	4.00
Respondent 11	4	3	4	3.67
Respondent 12	4	4	4	4.00
Respondent 13	4	4	2	3.33
Respondent 14	4	4	4	4.00
Respondent 15	4	2	4	3.33
Respondent 16	4	3	4	3.67
Respondent 17	2	4	4	3.33
Respondent 18	3	2	4	3.00
Respondent 19	4	4	2	3.33
Respondent 20	4	4	3	3.67
Respondent 21	2	3	4	3.00
Respondent 22	3	4	4	3.67
Respondent 23	4	3	4	3.67
Respondent 24	4	2	4	3.33

Respondent 25	3	2	3	2.67
Respondent 26	3	2	3	2.67
Respondent 27	4	4	3	3.67
Respondent 28	3	4	3	3.33
Respondent 29	3	3	4	3.33
Respondent 30	4	3	4	3.67
Overall Weighted Mean	**3.5**	**3.47**	**3.57**	**3.44**

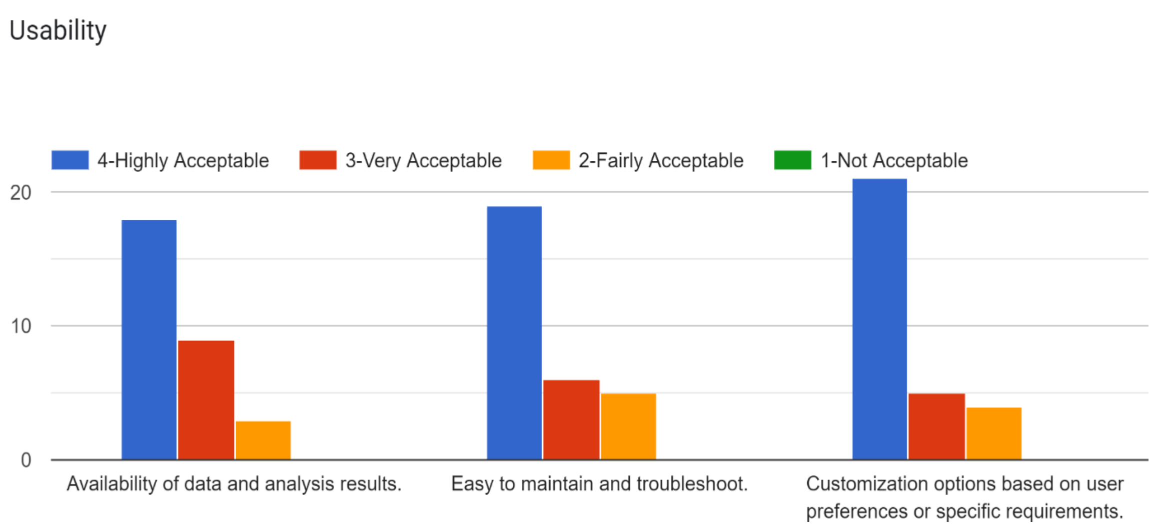


Figure 31. Evaluation Results for Usability

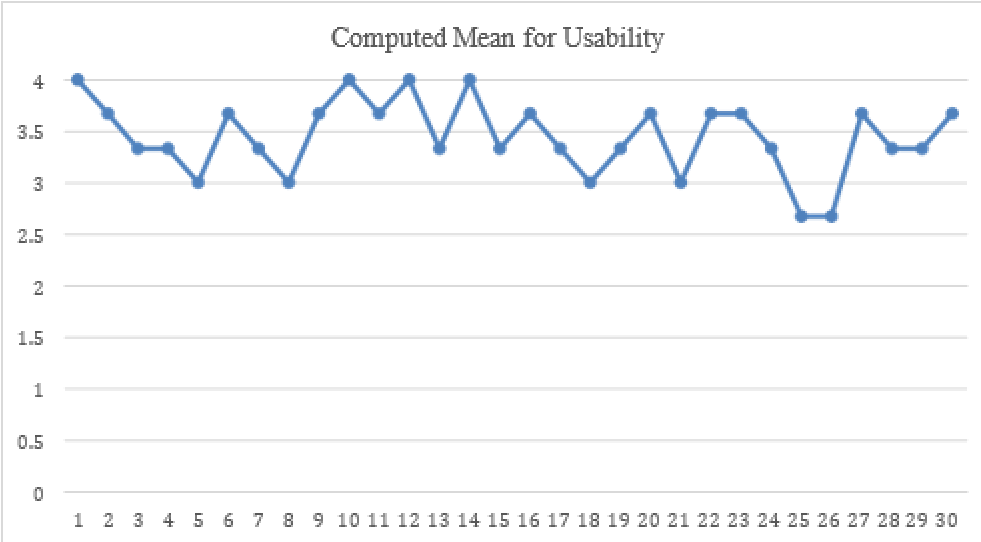


Figure 32. Computed Weighted Mean for Usability

Reliability

The Reliability criteria has three indicators to be answered: 1) Consistency in detection accuracy across different conditions, 2) The durability of hardware components, and 3) Proven reliability in real-world deployments. There was a total of 30 respondents who were able to take part and answer the evaluation. Every participant was assigned a number ranging from 1 to 30. The evaluation utilized a rating scale ranging from 1 to 4, where a rating of 4 represents the highest rating, and 1 the lowest rating. Figure 33 illustrates a graphical representation of the responses. The bars represent each of the acceptance levels, where the blue bar corresponds to a rating of Highly Acceptable, the orange bar corresponds to Very Acceptable, the yellow bar corresponds to Fairly Acceptable, and the green bar corresponds to Not Acceptable. The weighted mean for the Compatibility criteria was calculated as 3.42 (Very Acceptable).

Table 24.

Evaluation Results and Weighted Mean Computation for Reliability

RESPONDENTS	Question 1	Question 2	Question 3	Weighted Mean
Respondent 1	4	4	4	4.00
Respondent 2	4	4	4	4.00
Respondent 3	4	3	4	3.67
Respondent 4	4	4	4	3.00
Respondent 5	2	4	4	3.33
Respondent 6	3	4	4	3.67
Respondent 7	4	4	3	3.67
Respondent 8	4	4	4	4.00
Respondent 9	2	1	4	2.33
Respondent 10	4	4	4	4.00
Respondent 11	1	4	4	3.00
Respondent 12	4	4	4	4.00
Respondent 13	4	4	4	4.00

Respondent 14	4	4	2	3.33
Respondent 15	4	3	3	3.33
Respondent 16	4	3	2	3.00
Respondent 17	4	4	1	3.00
Respondent 18	4	2	3	3.00
Respondent 19	4	4	2	3.33
Respondent 20	4	4	2	3.33
Respondent 21	4	2	1	2.33
Respondent 22	3	4	3	3.33
Respondent 23	4	1	4	3.00
Respondent 24	4	2	4	3.33
Respondent 25	3	2	4	3.00
Respondent 26	3	4	4	3.67
Respondent 27	4	4	4	4.00
Respondent 28	3	4	4	3.67
Respondent 29	3	4	4	3.67

Respondent 30	3	4	4	3.67
Overall Weighted Mean	**3.53**	**3.43**	**3.4**	**3.42**

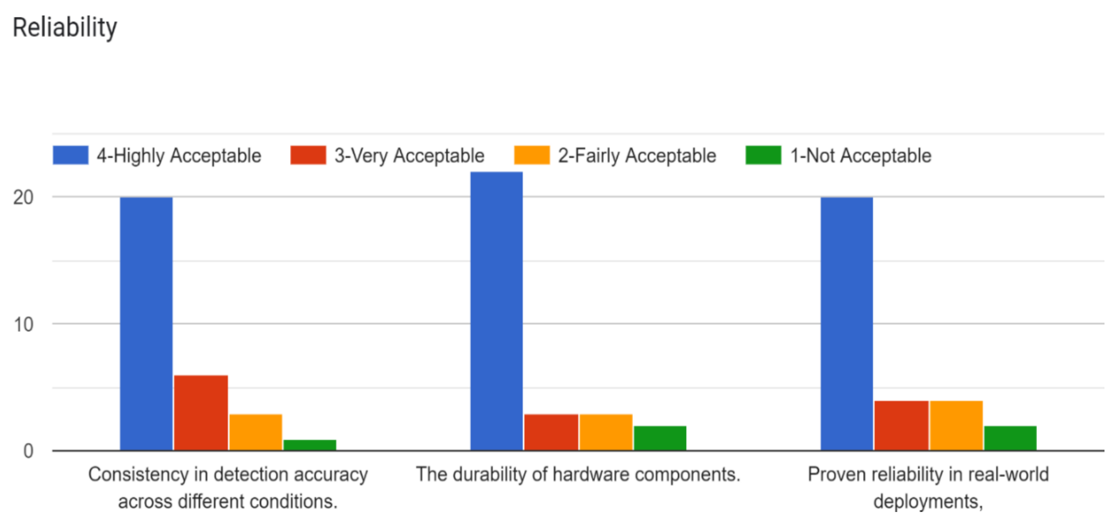


Figure 33. Evaluation results for Reliability

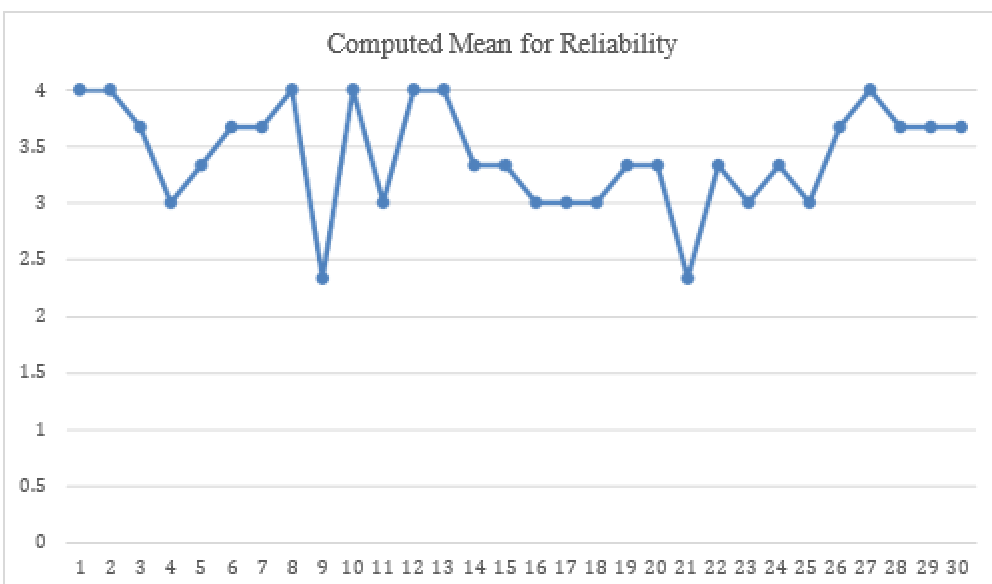


Figure 34. Computed Weighted Mean for Reliability

Maintainability

The Maintainability criteria has one indicator to be answered: 1) Availability of technical support or maintenance services. There was a total of 30 respondents that were able to take part and answer the evaluation. Every participant was assigned a number ranging from 1 to 30. The evaluation utilized a rating scale ranging from 1 to 4, where a rating of 4 represents the highest rating, and 1 the lowest rating. Figure 35 illustrates a graphical representation of the responses. The bars represent each of the acceptance levels, where the blue bar corresponds to a rating of Highly Acceptable, the orange bar corresponds to Very Acceptable, the yellow bar corresponds to Fairly Acceptable, and the green bar corresponds to Not Acceptable. The weighted mean for the Compatibility criteria was calculated as 3.47 (Very Acceptable).

Table 25.

Evaluation Results and Weighted Mean Computation for Maintainability

RESPONDENTS	Question 1	Weighted Mean
Respondent 1	4	4.00
Respondent 2	3	3.00
Respondent 3	4	4.00
Respondent 4	3	3.00
Respondent 5	4	4.00

Respondent 6	3	3.00
Respondent 7	4	4.00
Respondent 8	4	4.00
Respondent 9	4	4.00
Respondent 10	4	4.00
Respondent 11	4	4.00
Respondent 12	3	3.00
Respondent 13	2	2.00
Respondent 14	4	4.00
Respondent 15	4	4.00
Respondent 16	3	3.00
Respondent 17	4	4.00
Respondent 18	4	4.00
Respondent 19	3	3.00
Respondent 20	4	4.00
Respondent 21	4	4.00

Respondent 22	2	2.00
Respondent 23	2	2.00
Respondent 24	4	4.00
Respondent 25	2	2.00
Respondent 26	4	4.00
Respondent 27	2	2.00
Respondent 28	4	4.00
Respondent 29	4	4.00
Respondent 30	4	4.00
Overall Weighted Mean	**3.47**	**3.47**

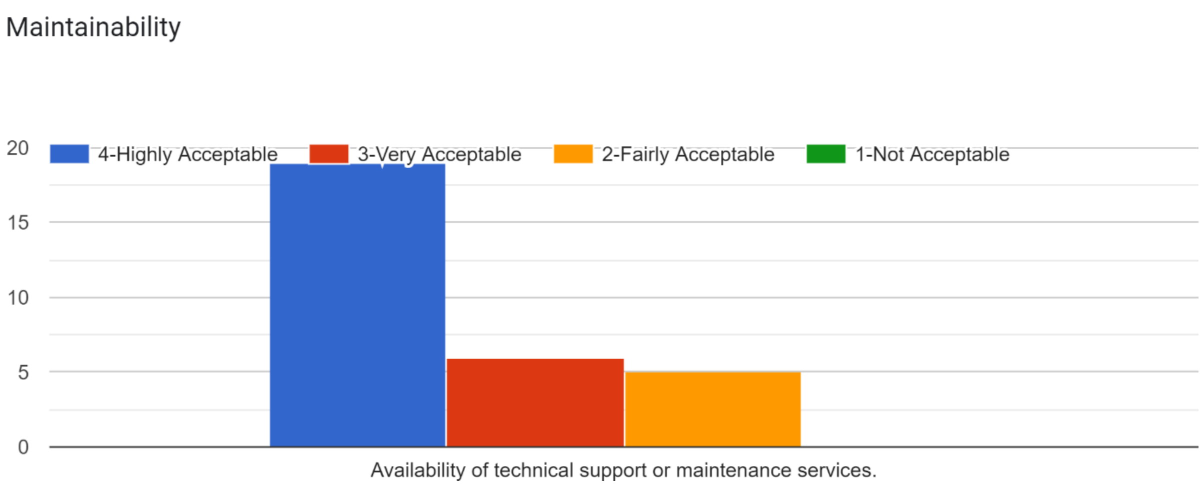


Figure 35. Evaluation Results for Maintainability

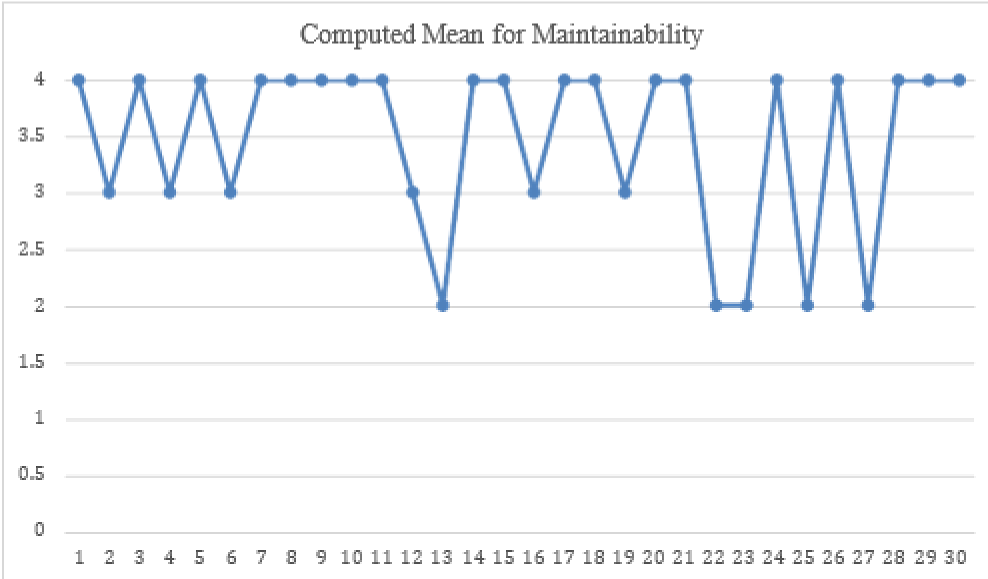


Figure 36. Computed Weighted Mean for Maintainability

Post-deployment of Water-based Dispersant

Figure 37. Oil after the Deployment

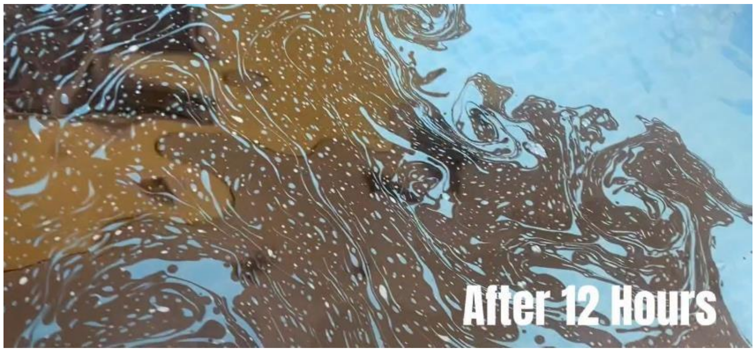


Figure 38. Oil after 12 Hours Observation

Figure 39. Oil after 24 Hours Observation

Figure 37 shows the effect of oil minutes after the deployment of water-based dispersant. The oil started to breakdown into tiny droplets. In Figure 38, it shows the effect of the dispersant after 12 hours. Oil has been broken down into tiny droplets that are spread across the water's surface. The intricate patterns and swirls of oil droplets show the formation of an emulsion. In Figure 39, after the 24-hour observation, the oil was reduced, and the water is now unclear. The water droplets dispersed throughout the water column where it shows the efficiency of the dispersant.

Chapter 5

SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

This chapter presents the summary of findings, conclusions, and formulated recommendations based on the results of testing and evaluation.

Summary of Findings

The purpose of developing Smart Oil Saver was to evaluate the impact and benefits of an oil spill cleaning device. After conducting the tests and evaluation for the system's overall performance, the following are the findings of the study:

The Smart Oil Saver was developed based on the objectives of the study, as well as its scope and limitations. The prototype device was developed to detect oil in the surface area of water and to deploy chemical dispersants to counter the oil spill. Microsoft Lobe was used to pre-train the device to classify the difference between water and lubricating oil. However, an issue arose when importing the lobe file into Python code, causing an error in detecting oil. The device features real-time monitoring of the testing area using the web camera. Additionally, it includes an A9G module for effective SMS notification, sending alert messages to the user when oil is detected, and a diaphragm water pump powered by a relay to disperse the chemical dispersant.

A 24- hour observation was conducted after dispersing chemical dispersant to the oil slick. In the first minute, the researchers observed that the oil started to penetrate and reach the oil and water interface. The presence of wave action helped to spread the water-based dispersant to effectively break off the oil slick into micronized oil droplets. After 12 hours, oil has been broken down into tiny droplets that are spread across the water's surface.

The intricate patterns and swirls of oil droplets showed the formation of an emulsion, which is when oil and water are mixed resulting in the change of color of the water. The presence of the oil droplets indicated that the oil has a larger surface area exposed to water, allowing for more efficient microbial degradation. After 24 hours, the oil dispersant's efficiency is clear, it has reduced the size of the oil resulting in better dispersion throughout the water column. The oil droplets are more uniformly dispersed, indicating a more homogeneous spread caused by the dispersant. Furthermore, a reduction in huge, concentrated oil slicks reduces the immediate environmental impact on marine life and shorelines.

A survey evaluation was conducted with different groups of professionals which involves Engineers, Architect, IT Professionals, and the Philippine Coast Guard. The prototype device was evaluated using the Technological University of the Philippines (TUP) Evaluation Instrument for the developed prototype. The Smart Oil Saver received a “Very Acceptable” rating with a grand weighted mean of 3.48.

Conclusions

Based on the results of testing and evaluation on the prototype device, the following conclusions were formulated:

1. As specified in the Objectives of the Study, the prototype was developed successfully. Features that served as indicators for the success are as follows:
    a. Real-time monitoring on the testing area.
    b. Able to send alert messages to notify the user about the detected oil.
    c. Able to detect lubricating oil using machine learning.
    d. Able to deploy chemical dispersant.
2. The prototype device was successfully developed using the hardware and software tools which include Raspberry Pi, TFT Touchscreen LCD, Water Pump, A9G module, Relay, Webcam, Microsoft LOBE, Tensorflow, and Python.
3. The prototype device was tested that it can detect oil and deploy dispersant.
4. The developed prototype device was evaluated as Very Acceptable in terms of functionality, accuracy, reliability, and maintainability which proves that the Smart Oil Saver can be helpful in future oil spill response.

Recommendations

The testing results of the prototype device revealed that the study Smart Oil Saver: an ARM-based Oil Spill Cleaning Device using Machine Learning is a necessary foundation for further development of remote oil spill detection and clean-up solution.

The following recommendations are proposed to future researchers to enhance the existing prototype design:

1. Improve the overall design of the prototype device to be more secure. This is to enable the hardware components to withstand different environmental conditions.
2. Optimization of hardware components for better results and features that can help to maximize its full capabilities.
3. Implement an IoT platform so that the users can manage and monitor the data easily.
4. To get more accurate results, find a more advanced camera and other remote sensing technologies.
5. Collaborate with different government agencies, engineers, chemists to have a wider range of knowledge about different types of oils and other cleaning techniques.
6. Train and test other types of oils and different cleaning techniques.

By implementing these recommendations, future researchers and professionals can enhance the prototype design for the development of remote oil spill solution technology based on the current study.

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APPENDICES

Appendix A

Hardware Requirements Specification

The Smart Oil Saver (SOS): Arm based Oil Spill Cleaning device using Machine Learning, is suitable for the following recommended hardware services that will aid in the advancement of the system study.

Table 1

Raspberry Pi 4 Model B Hardware Requirements and Specification

Hardware Requirements	Specification
SoC	Broadcom BCM2711, Quad core Cortex-A72 (ARM v8) 64-bit SoC @ 1.8GHz
Memory	4GB LPDDR4-3200 SDRAM
Storage	Micro SD card
Power	5V 3A USB-C power supply
Other ports	2 x micro-HDMI ports, 2 x USB 3.0 ports, 2 x USB 2.0 ports, Raspberry Pi standard 40 pin GPIO header, 2-lane MIPI DSI display port, 2-lane MIPI CSI camera port, 4-pole stereo audio and composite port.
Wireless	2.4 GHz and 5.0 GHz IEEE 802.11ac wireless, Bluetooth 5.0, BLE

Ethernet	Gigabit Ethernet

Table 2

Touch Screen Display Hardware Requirements and Specification

Hardware Requirements	**Specification**
Screen Size	7 Inches
Display Type	LCD
Touch Point	5-Points
Resolution	1024 x 600
Display Port	HDMI
Touch Port	USB

Table 3

Arduino Uno Hardware Requirements and Specification

Hardware Requirements	Specification
Microcontroller	ATmega328P
Operating Voltage	5V
Digital I/O Pins	14 digital I/O pins
Analog I/O	6 analog input pins
Other	A14 LED, ICSP header, reset button, USB connection

Table 4

Ultrasonic Sensor Hardware Requirements and Specification

Hardware Requirements	Specification
Power Supple	5V DC
Operating current	15-20mA
Working frequency	40kHz

Ranging distance	2cm to 400 cm
Resolution	0.3cm
Measuring angle	15 degrees
Trigger input pulse width	10uS

Table 5

Raspberry Pi Camera Hardware Requirements and Specification

Hardware Requirements	**Specification**
Imager sensor	Sony IMX477
Resolution	5 megapixels (2592 x 1944 pixels)
Sensor size	1/4’’
Pixel size	1.4 µm
Lens	Fixed focus
Aperture	f/2.8
Field of view	53.4° (horizontal)
Frame rate	Up to 25 fps

Video resolution	Up to 1080p30
Video compression	H264 and MJPEG
Image format	JPEG and BMP
Interface	MIPI CSI-2
Power consumption	250 mW
Dimensions	25mm x 20mm x 9mm

Table 6

Relay module Hardware Requirements and Specification

Hardware Requirements	Specification
Supply voltage	3.75V to 6V
Quiescent current	2mA
Current when relay is active	70mA
Relay maximum contact voltage	250VAC or 30 VDC
Relay maximum current	10A

Table 7

Temperature Sensor DS18B20 Hardware Requirements and Specification

Hardware Requirements	**Specification**
Power supply	3.3V or 5V DC
Temperature range	-55°C to +125°C
Resolution	12 bits
Accuracy	±0.5°C
Power consumption	0.5µA
Communication protocol	One-wire
Package	TO-92

Table 8

A9G GSM Hardware Requirements and Specification

Hardware Requirements	Specification
Power supply	5V DC
Operating current	40 mA
Peak current	2A
GSM frequency	850/900/1800/1900 MHz
GPS frequency	1575.42 MHz
Module	Ai Thinker A9G
Standby Current	< 2mA
Operating Voltage	3.3V – 4.2V

Table 9

Solar Panel Hardware Requirements and Specification

Hardware Requirements	**Specification**
Power Output	200 watts
Efficiency	18-22%
Open-circuit voltage	35-47 volts
Short-circuit current	5-6 amperes
Dimensions	1560 x 770 x 35mm
Weight	17-20 kg
Temperature range	-40°C to +85°C

Table 10

Lead Acid Battery Hardware Requirements and Specification

Hardware Requirements	Specification
Voltage	12V
Capacity	5Ah to 200Ah
Energy storage	60Wh to 2400Wh
Discharge current	5A to 200A
Charging current	0.5A to 20A
Weight	5kg to 25kg
Dimensions	150mm x 130mm x 65mm

Table 11

30A-MPPT Solar Controller Hardware Requirements and Specification

Hardware Requirements	Specification
Current	30A
Voltage	12V/24V/48V auto
Maximum PV input voltage	75V
MPPT tracking efficiency	>99%
Conversion efficiency	>98%
Dimensions	165mm x 100mm x 58mm
Temperature range	-20°C to +60°C

Table 12

Water sprinkler Hardware Requirements and Specification

Hardware Requirements	Specification
Current	30A
Voltage	12V/24V/48V auto
Maximum PV input voltage	75V
MPPT tracking efficiency	>99%
Conversion efficiency	>98%
Dimensions	165mm x 100mm x 58mm
Temperature range	-20°C to +60°C

Table 13

Water flow Sensor Hardware Requirements and Specification

Hardware Requirements	Specification
Power Supply	5V or 12V DC
Accuracy	±2% of full scale
Response time	Less than 1 second
Operating temperature range	-20°C to +85°C

Appendix B

Software Requirements Specification

The Smart Oil Saver (SOS): An Arm-Based Oil Spill Cleaning Device using Machine Learning has a software specification required for the software system to be developed in this study.

Table 14

Operating System Software Requirements and Specifications

Software Requirements	Specifications
Raspberry Pi OS	64 – bit
Ubidots	64 – bit
Tensor Flow	64 – bit
Microsoft LOBE	64 – bit

Program Requirements Specification

The Smart Oil Saver (SOS): An Arm-Based Oil Spill Cleaning Device using Machine Learning, software system development in the study's programming and coding necessitates the establishment of program specifications.

Table 15

Programming Languages and Specification

Program Requirements	Platform
Python	ThonnyIDE

Appendix C

Bills of Expenses

Raspberry pi 4GB 4B	Php 11,000
Battery	Php 6,000
Solar Panel	Php 5,500
Swimming Pool + Shipping Fee	Php 5,300
Drum + Shipping Fee	Php 3,300
Improvised Floaters	Php 3,612
Inverter	Php 2,800
TFT 7inch Touchscreen	Php 2,100
Oil Dispersant	Php 2,000
Coral	Php 2,000
Pump machine for sea Water	Php 2400
Camera	Php 1,200
GSM	Php 1,200
Charge Controller	Php 1,200
SSD 128 GB	Php 720
12v Pump	Php 660
Aquaspeed A3000 (16W)	Php 592
Adaptor	Php 450
Casing	Php 450
Hose	Php 400

Duct Tape	Php 400
Adhesive	Php 384
Wire	Php 300
12w Stranded Wire	Php 200
Antenna	Php 250
Extension	Php 199
12V R385 Water Pump diaphragm type	Php 159
Data Cable	Php 150
Solar Panel Connector (Pair)	Php 150
18w Stranded Wire	Php 60
Relay	Php 130
Total :	Php 55,266

Appendix D

TUP EVALUATION INSTRUMENT FOR PROTOTYPE DEVELOPMENT

SURVEY FORM

Smart Oil Saver (SOS): An Arm-based Oil Spill Cleaning Device using Machine Learning

Greetings!

We are a group of fourth-year students pursuing a Bachelor of Science in Information Technology at Technological University of the Philippines-Manila. And we're conducting a study entitled "Smart Oil Saver (SOS): An Arm-based Oil Spill Cleaning Device using Machine learning."

We respectfully ask for your participation in a survey so that we can assess the effectiveness of the prototype device and know your opinions. And by completing the survey, you are granting your consent to be part of this study. Thank you for your participation!

Attached below is the video demonstration of our prototype device.
CLICK HERE TO WATCH OUR SOS VIDEO DEMONSTRATION

catherineanne.alcala@tup.edu.ph Switch account

* Indicates required question

Email *

Your email

Which part of the profession are you? *

- ◯ Philippine Coast Guard
- ◯ Engineer
- ◯ Architect
- ◯ IT Professional

INSTRUCTION

Evaluate the system using the provided scale and put a checkmark next to the corresponding numerical rating.

Functionality *

	4-Highly Acceptable	3-Very Acceptable	2-Fairly Acceptable	1-Not Acceptable
Accuracy in oil detection	◯	◯	◯	◯
Speed of the detection procedure	◯	◯	◯	◯
The range and width of the camera to detect oil	◯	◯	◯	◯
The ability to distinguish between oil and water.	◯	◯	◯	◯

Compatibility *

	4-Highly Acceptable	3-Very Acceptable	2-Fairly Acceptable	1-Not Acceptable
Integration with other platforms or systems.	○	○	○	○

Efficiency *

	4-Highly Acceptable	3-Very Acceptable	2-Fairly Acceptable	1-Not Acceptable
The processing speed of machine learning algorithms.	○	○	○	○
Scalability to handle huge amounts of data	○	○	○	○
Minimization of having false positives or negatives	○	○	○	○

Performance Efficiency *

	4-Highly Acceptable	3-Very Acceptable	2-Fairly Acceptable	1-Not Acceptable
Consistent detection of oil over time	○	○	○	○
The response time to changes in oil.	○	○	○	○
Capable of handing multiple detection tasks simultaneously.	○	○	○	○
Minimization of error or inaccuracies in detection results.	○	○	○	○

Usability *

	4-Highly Acceptable	3-Very Acceptable	2-Fairly Acceptable	1-Not Acceptable
Availability of data and analysis results.	○	○	○	○
Easy to maintain and troubleshoot.	○	○	○	○
Customization options based on user preferences or specific requirements.	○	○	○	○

Reliability *

	4-Highly Acceptable	3-Very Acceptable	2-Fairly Acceptable	1-Not Acceptable
Consistency in detection accuracy across different conditions.	○	○	○	○
The durability of hardware components.	○	○	○	○
Proven reliability in real-world deployments,	○	○	○	○

Maintainability *

	4-Highly Acceptable	3-Very Acceptable	2-Fairly Acceptable	1-Not Acceptable
Availability of technical support or maintenance services.	○	○	○	○

Recommendations / Comments *

Your answer

Back Submit Clear form

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- Knowledgeable in HTML, CSS, PHP and MySQL
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- Can perform basic SQL Queries and manage Database
- Can do Basic routing on Cisco Packet Tracer
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- Knowledgeable in HTML and CSS
- Knowledgable in Web Development
- Can do basic routing
- Microsoft Office

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BACHELOR OF SCIECE IN INFORMATION TECHNOLOGY
TECHNOLOGICAL UNIVERSITY OF THE PHILIPPNES - MANILA
2020-2024

SAINT DOMINIC COLLEGE OF ASIA
Molino Bacoor Cavite
2018-2020

SAINT THOMAS MORE ACADEMY
Molino Bacoor Cavite
2014-2018

KNOWLEDGE AND SKILLS

- Coding Languages: Python, JavaScript, CSS, PHP, SQL, C++, C, Java
- Operating System: Windows, MacOS, Linux
- Artificial Intelligence: Machine Learning
- Database Administration: MySQL
- Network: Cisco, LAN Technology
- Hardware and Microsoft Office

CHRISTINE GRACE G. POLON

Block 51 Lot 1 Phase 4, Mabuhay Homes
2000, PaliparanII, Dasmariñas City, Cavite
09675621080
christine.grace.polon@gmail.com

WORK EXPERIENCE

TORK PHILIPPINES INC.
MARCH 2024-JUNE 2024

EDUCATION BACKGROUND

BACHELOR OF SCIECE IN INFORMATION TECHNOLOGY
TECHNOLOGICAL UNIVERSITY OF THE PHILIPPNES - MANILA
2020-2024

MUNTINLUPA NATIONAL HIGH SCHOOL MAIN
STEM STRAND
2018-2020

LAKEVIEW INTEGRATED SCHOOL
JUNIOR HIGH SCHOOL
2017-2018

KNOWLEDGE AND SKILLS

- Knowledgeable in HTML, CSS, PHP and MySQL
- Hardware Trouble Shooting
- Network Trouble Shooting
- Basic routing on Cisco Packet Tracer
- Programming Languages (Java, C, C++, Phyton)
- Microsoft Office
- Photoshop