Design of android based Unmanned Surface Vehicles (USV) for oil spill monitoring

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Abstract. In this research, a USV will be developed that can detect oil spills on the waters, so in the future it can overcome the problem of water pollution. To be able to determine the thickness of the oil on the water surface, TEMT6000 and LED sensors are used. The light intensity will be converted into ADC value by the TEMT6000 sensor. Furthermore, on this system USV will be controlled by Android and can monitor water surface conditions. Android applications will be connected to Wemos via wifi. Then Wemos is connected serially with a RF915 and another RF915 will be connected to the microcontroller of the USV. From the results of the USV test, the USV can be controlled via Android by moving forward, backward, turning left and right. The maximum range of RF915 is 493.3 meters. Then the oil spill detection average error is 5.45% and the the average of the success rate is 94.55%.

1. Introduction
Recently the industry is experiencing a very rapid development. With the increasing number of industrial companies, the more waste is produced which has the potential to pollute the environment. Industrial waste is waste originating from industrial activity discharges which can be in the form of solid, liquid, or gas. If the waste is not treated first, it can pollute the environment which can have a negative impact on the ecosystem of living things around the waste disposal site.

Apart from industrial waste, environmental pollution can also be caused by work accidents resulting in pipe leaks, sinking of oil-carrying vessels which results in oil spilling. According to data from the Ministry of Energy and Mineral Resources from 2013 to 2017, the highest oil spill was in 2017 with 2071 barrels and the lowest in 2014 with 46 barrels [1]. The number of oil spills increased throughout 2018 and 2019. On January 10, 2019, a tanker owned by PT Sochi experienced an oil leak that polluted the waters in Pare-Pare, South Sulawesi [2]. This can be detrimental to local fishermen who cannot go to ocean because of the oil spill in their fishing area.

In the same year, PT PERTAMINA’s pipeline leak resulted in an oil spill of 39 thousand barrels and 5 million sacks in Karawang [3]. In the short term, an oil spill in Karawang can cause a decrease in the quality of ocean and coastal water, the death of several types of fish and shellfish [4]. The problem of oil spills must be addressed before it causes the death of the marine biota. Apart from being at ocean, a leaky pipe belonging to PT PERTAMINA in the Tasikmalaya area also caused 45 residents’ fishponds to be polluted by diesel fuel [5]. This also gives quite a lot of losses for people who have the main job as a owners of fishing ponds and fish breeders.
For this reason, a right technique is needed to detect an oil spill. In previous research, a USV (Unmanned Surface Vehicle) was made that can monitor water quality with pH as a parameter [6]. In this paper, a design and development of a oil spill detection using an Android-based USV (Unmanned Surface Vehicle) is expected to solve the problem of oil spills in the water if there is further development in the future.

In 2013, research conducted by Sangwoo Oh and Moonjin Lee entitled Detection of Hydrocarbon Oil in Seawater by Light Absorption Analysis. In this research, a sensor design that can detect the presence of oil spills and its thickness on the water surface is made using a photodiode and LED sensor [7]. If there is oil on the surface of the water, the light intensity emitted by the LED also decreases. Then the thickness of the oil can be predicted through an LDR sensor that detects the light intensity from the LED.

In 2018, research conducted by Bagus Aris Saputra et al entitled Design and Build of Water-Oil Separation Systems Based on Microcontroller Teensy. In this study the design was made to detect the presence of oil on the water can be done by adding a laser from below the surface of the water on the Ldr sensor which is above the surface of the water, then carried out oil absorption using a diaphragm pump. However, this system has not been applied to the USV (Unmanned Surface Vehicle) which can move to absorb oil, the thickness of the oil cannot be monitored using a laptop or smartphone [8].

In 2019, research conducted by Jo et al with the title A low-cost and small USV platform for water quality monitoring. In this research, a design of USV (Unmanned Surface Vehicle) was made which is used to monitor river water conditions around industrial areas [6].

Based on previous research, the authors developed a USV prototype to detect spill. This study develops the first research, then applies it to USV and the detected thickness data can be displayed on the android application.

2. Methodology
2.1. System Design

![System Design Diagram](image-url)

**Figure 1.** System Design.
The system design shown in Figure 1 allows data to be sent from Android to USV, with Android sending data to Wemos via WiFi using the UDP protocol. Wemos will then transmit data obtained from Android to RF915 via serial communication. RF915 will send data to another RF915 located on the USV, where the data is read by a microcontroller through serial communication. To send sensor data, the opposite process is followed, starting with the microcontroller reading the TEMT6000 sensor and sending data serially to RF915. Then, RF915 from the ship will send the data to the connecting station RF915. RF915 will then send the data serially to Wemos, and finally, Wemos will send data to Android via WiFi with UDP communication.

2.2. USV Design
The USV (Unmanned Surface Vehicle) that will be created will have three main dimensions: 70 cm long, 35 cm wide, and 11 cm high.

From some of the images above, Figure 2 shows the initial USV design view isometric. In accordance with the image above, the following is an explanation of the placement of components on the USV:

1. The electric circuit is a circuit consisting of a microcontroller and an actuator, which functions to move the ship, read the sensor and carry out oil extraction.
2. The tank will be placed on both hulls of the ship to store oil that has been sucked from the water surface.
3. The sensor on the USV is a design of the TEMT6000 sensor that detects the light intensity of the LED that shoots light at the TEMT6000. The position of the LED is below the water level and the TEMT6000 is above the water level.
4. The buoy functions to support the hose and the TEMT6000 sensor circuit, which will suck up oil spill samples.

2.3. Sensor Placement Design
To measure oil thickness using LEDs and TEMT6000, the laser is placed in the water and scanned to the surface of the water. The laser light intensity will be measured by the TEMT6000. The oil thickness above the water surface will affect the light intensity received by TEMT6000, then this is used to predict the thickness of the oil. Figure 3 below is the layout design for the LED and TEMT6000.
Figure 3. Placement of the LED and TEMT6000.

2.4 Android App Design
The android application that will be used has 2 main pages, namely monitoring and control as shown in Figure 6 and Figure 7. Then when you open it for the first time, a loading page will appear as shown in Figure 4. To switch from the control page to monitoring as well as preferably there is a menu page as shown in Figure 5.

Figure 4. Android Application Loading Page.

Figure 5. Android Application Menu Page.
Figure 6. Android Application Monitoring Page.

Figure 7. Android Application Control Pages.

Following is the description according to the interface design in Figure 9 and Figure 10:
1. A gauge that displays the detected oil thickness in millimeters (mm).
2. The oil pump indicator shows the condition of the oil suction pump on or off.
3. Indicator of tankage on vessels with a range of 0-100%.
4. Graph of the detected oil thickness in millimeters (mm).
5. Button to activate and deactivate the oil-suction pump.
6. Button to move the ship to turn left.
7. Button to move the ship moving to the right.
8. Seekbar to set the boat speed from 0% to 100%.
9. Button to move the ship forward.
10. Button to move the ship backwards.
3. Result and Discussion

3.1. USV Design Result
USV is the main hardware in this final project, this USV has a catamaran type or two right and left hulls. This USV is made of balsa wood. The specifications of this USV include the following:

- Length: 75 cm
- Width: 40 cm
- Height: 11 cm
- Oil Tank Capacity: 2 Liters

The reason for using the catamaran hull is that the right hull and left hull can be installed with an oil transport tank to take oil samples by absorption method. This is shown on the inside of the USV as Figure 8. Following Figure 9 which shows the isometric view of the USV.

As shown in Figure 8 and Figure 9, the front of the USV has a buoy which functions to support the TEMT6000 sensor circuit to float on the water surface so that it can detect oil spills on the water surface. In addition, the float also functions to support the suction hose so that it can suck up oil samples. The buoy can move up and down so that when the water laden from USV rises due to oil holding, the position of the TEMT6000 sensor circuit and the oil suction hose remain in the same position on the water surface.

3.2. RF915 Holybro Range Test Result
This test is carried out by connecting a Holybro RF915 with a powerbank using a USB cable while the other Holybro RF915 is already in the connecting station as in Figure 10. Then wait until the two are connected to each other with the green LED indicator lights up constantly. The connecting station is placed in the fixed place then the coordinates are recorded with GPS, then the RF915 Holybro which is connected to the powerbank is taken to another place by vehicle until the two radios are not con-
nected. Furthermore, the GPS coordinates where the last time the two radios were still connected were recorded. Here are the coordinates of the two radios and the distance is about 493.30 meters as in Figure 11.

1st Holybro RF915 = -7.2700309,112.8048667
2nd Holybro RF915 = -7.2657331,112.8037614

Figure 10. Connecting Station and RF915 Test.

Figure 11. Connecting Station and RF915 Test Result.

3.3. Oil Spill Detection Result
This test is done by spilling oil (diesel fuel) on the water in the aquarium. Oil will be spilled on the surface of the water with a certain thickness then ADC data will be recorded. Figure 12 shows the TEMT6000 sensor testing to retrieve ADC data from the light intensity emitted by the LED. The following Table 1 is the result of ADC data from the taking made on the TEMT6000 sensor.
As in the experimental results above, the ADC value of the TEMT 6000 sensor is directly proportional to the intensity of the light hitting the sensor. The higher the light intensity, the greater the ADC value.

The graph in Figure 13 shows the relation between oil thickness and ADC that is read quite linear. After obtaining this data, the data is made a graph of the response to the effect of oil thickness on ADC which is read by the TEMT6000 sensor as in Figure 13 where the x-axis is the ADC value and the y-axis is the thickness of the oil. From this graph, using Microsoft Excel, we get a trendline with functions such as Equation 1 below:

\[ y = -0.1037x + 28.748 \] (1)
With:
\[ y = \text{oil thickness (mm)} \]
\[ x = \text{TEMT6000 ADC output} \]

**Figure 13.** Oil Thickness vs ADC Value Graph.

Then the ADC value is converted to oil thickness according to Equation 1. The following Table 2 is a table of detection results with the errors.

| Ruler (mm) | Sensor (mm) | Error (%) |
|------------|-------------|-----------|
| 20         | 20          | 0         |
| 18         | 18          | 0         |
| 16         | 16          | 0         |
| 14         | 14          | 0         |
| 12         | 12          | 0         |
| 10         | 9           | 10        |
| 8          | 8           | 0         |
| 6          | 6           | 0         |
| 4          | 4           | 0         |
| 2          | 3           | 50        |
| 0          | 0           | 0         |

**Average Error (%)**

5.45

4. Conclusion

The conclusion is that USV can be controlled via Android by moving forward, backward, turn left and turn right. Maximum range of RF915 is 493.3 meters. Then the oil detection system average error is 5.45% and the average of success rate is 94.55%. 
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