A flamethrower mounted on UAV for kite litter clearing on high voltage transmission line

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ABSTRACT

The high voltage transmission line (HVTL) is a part of the electric power transmission system that distributes high-capacity electricity. There were numerous interruptions to the transmission line, one of which was caused by the kite getting stuck in the conductor. In the past, interference from kites on the conductor wire has been removed by crawling over it. This conventional method poses safety risks, is high-cost, and is time-consuming. This article describes the development of a flamethrower mounted on an unmanned aerial vehicle (UAV) for kite litter clearing on a high-voltage transmission line is presented. The flamethrower is fitted on the UAV to achieve high-mounted wire. The UAV was controlled using a transmitter and a receiver based on an Arduino. The flamethrower was tested for clearing a kite on the transmission line. The effect of nozzle diameter on flame burst length and the time it takes to burn a kite has been investigated. According to the experiment results, the performance of the flamethrower is highly satisfactory. Based on the component prices and manufacturing costs, the flamethrower has been successfully assembled at a low cost for a total of below $55.

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1. INTRODUCTION

Advances in technology, population and industry are driving the consumption of electrical energy. Consequently, the amount of electrical energy that must be supplied to consumers also increases as energy demand increases. This situation corresponds to the increasing number of high-voltage transmission lines (HVTL) required to transport electricity from distant power plants [1]–[4]. The construction of HVTL requires careful consideration of environmental issues and avoiding potential damage to the HVTL network [3]–[6]. HVTL areas should be separated from residential areas, above ground level and free of trees [3], [7], [8].

A crucial problem in HVTL [9] is the number of potential power outages, including those caused by typhoons [10], human activity [11], and lightning [12]. One of the human activities that commonly disturb HVTL is snagging kites. A kite or other foreign object entering an HVTL might cause a short circuit and ground discharge [13]–[15]. In the past, interference from kites on the conductor wire has been removed by crawling over it. This traditional approach is risky for safety, expensive, and time-consuming [4], [13], [15]. As a result, a novel, easy, and affordable kite-clearing technique needs to be created.

Based on the described problem, this work develops a flamethrower for eliminating kite debris on HVTL with unmanned aerial vehicle (UAV)-assisted. The flamethrower works by spraying fire to burn the kite. The unit is mounted on a UAV [16]–[18] and is remotely controlled via a transmitter and receiver module. The use of UAV is suggested in this study because it is more efficient, time-saving and cost-effective, especially for small-budget projects [4], [19]–[22]. The transceiver module (NRF24L01) provides connectivity between transmitter and receiver units. This module is often used in the development of wireless systems because it is reliable and inexpensive [3], [23], [24]. Generally speaking, the system is based on Arduino, so it is cheap and easy to use.

With all the conveniences offered by using a remotely enabled signal transfer system and utilizing UAV technology in managing the flamethrower to be more effective, this flamethrower will be very useful in clearing kite litter that often gets stuck at HTVL. Since the UAV can be controlled from a distance of 5km and has a maximum payload of 15 kg, it can lift the flamethrower system and fuel. The application of the flamethrower in clearing kite litter not only promotes efficiency but also saves costs because it uses components that are cheap and easily accessible.

2. METHOD

This flamethrower consists of several electronic components, including Arduino UNO, Arduino Nano, NRF24L01 module, power supply (battery), lighter and sprayer. In addition, there are supporting components such as oil pumps, oil tanks, oil pipes, stainless steel pipes and connecting cables. The flamethrower pipe is 1.3 m long with a sprayer at the end. All components are arranged horizontally on an acrylic sheet 40×30 cm. Figure 1 shows the scheme of the flamethrower system.

Flamethrower contains two controllers: an inside box controller (receiver) and an external controller (transmitter) that acts as a remote command sender. The controller box for this device contains an Arduino UNO, relays, switches, battery and NRF24l01 module. The tool’s controller is made up of an Arduino Nano, batteries, switches, the NRF24l01 module, and push buttons. The NRF24l01 module delivers a signal from a distance that is received by the receiver when the push button on the transmitter is depressed, enabling the lighter to function, fuel to flow through the oil hose, and the tool to spew fire. Figure 2 shows a photo of the system.

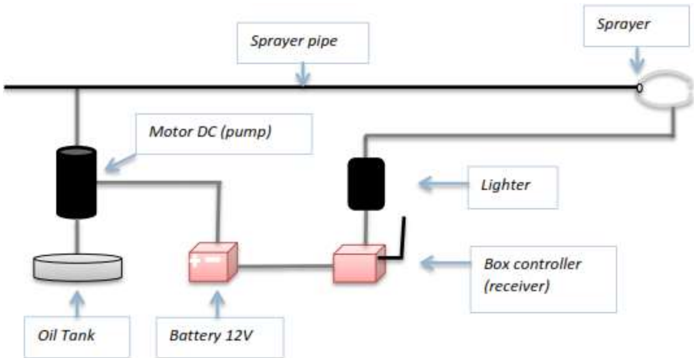

Figure 1. Schematic of flamethrower system

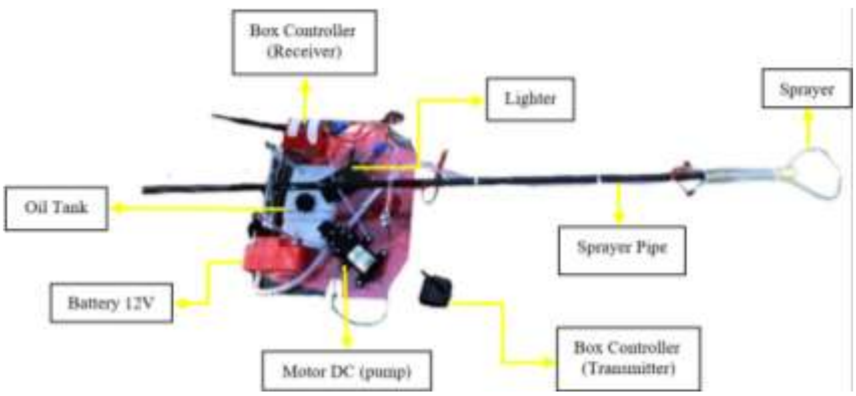

Figure 2. Photograph of a flamethrower unit system

Figure 2 shows a photograph of the assembled flamethrower system. For the flamethrower to reach the HVTL, a UAV Matrice 600 Pro is operated [22]. This UAV is frequently used in the development of flight instruments [25], [26]. The tool will be flown by the UAV until it reaches the HVTL. Figure 3 shows the UAV Matrice 600 Pro.

Figure 3. UAV Matrice 600 Pro

3. RESULTS AND DISCUSSION

3.1. Transmitter unit

The transmitter module consists of several components, including Arduino nano, battery, switch, push button, and transceiver module (NRF24L01). Figure 4 shows the design for the transmitter module circuit. The battery powers the Arduino Uno and also supplies the required voltage. The positive terminal of the battery is connected to the Arduino's Vin terminal, which is controlled by a switch that turns on and off the transmitter circuit. The ground component, meanwhile, is directly connected to the ground terminal (GND) on the Arduino. A push button is installed as a trigger button to activate the flamethrower. This push button is connected to Arduino pin 3 and also the ground. When the push button is pressed the pump and flamethrower are turned on.

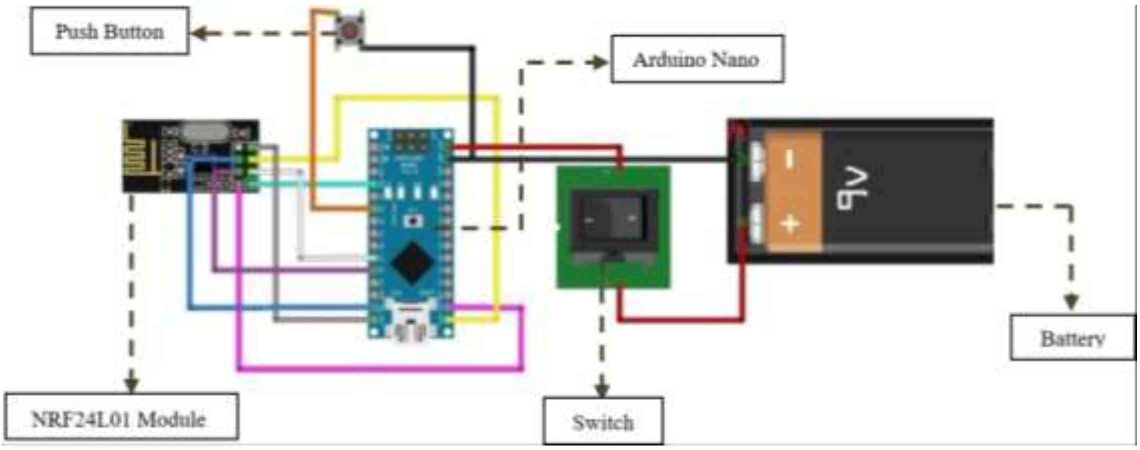

Figure 4. Transmitter circuit

To communicate with the receiver module, NRF24L01 is installed on the Arduino. On the transmitter unit, Arduino is programmed to send a signal to the receiver unit to turn on the DC pump and lighter. Arduino is programmed using the Arduino IDE application written in C++. This module has 7 pins that will be connected to the pins on the Arduino. Table 1 shows the configuration of transceiver pin connections with Arduino.

Table 1. Transceiver module connection to Arduino in transmitter unit

Transceiver pin	Arduino pin
VCC	3V3
Chip enable (CE)	D7
Chip serial not (CNS)	D8
Master output, slave input (MOSI)	D11
Master input, slave output (MISO)	D12
Serial clock (SCK)	D13
GND	GND

3.2. Receiver unit

The receiver unit in Figure 5 is assembled of various components and modules, including an Arduino UNO, NRF24L01 module, two relays, a switch, a DC motor (pump), a lighter, and a power source consisting of a 9V and 12V battery. A 12V battery powers the DC pump motor, while a 9V battery powers the Arduino. A normally open (NO) 5V relay serves as a controller for the DC motor pump. The relay input (Vin) is connected to Arduino pin A2, while VCC and GND Relay are connected to Arduino pins VCC and GND, respectively. At the same time as the first relay, the second relay is connected to the lighter. The NRF24L01 module is linked to the Arduino to communicate with the transmitter unit. The Arduino is programmed to control the DC motor pump and lighter based on the signal received from the transmitter unit. Table 2 shows the configuration of the connection between the NRF24L01 module and Arduino UNO.

Table 2. Transceiver module connection to Arduino in receiver unit

Transceiver pin	Arduino pin
VCC	3V3
Chip enable (CE)	7
Chip serial not (CNS)	8
Master output, slave input (MOSI)	11
Master input, slave output (MISO)	12
Serial clock (SCK)	13
GND	GND

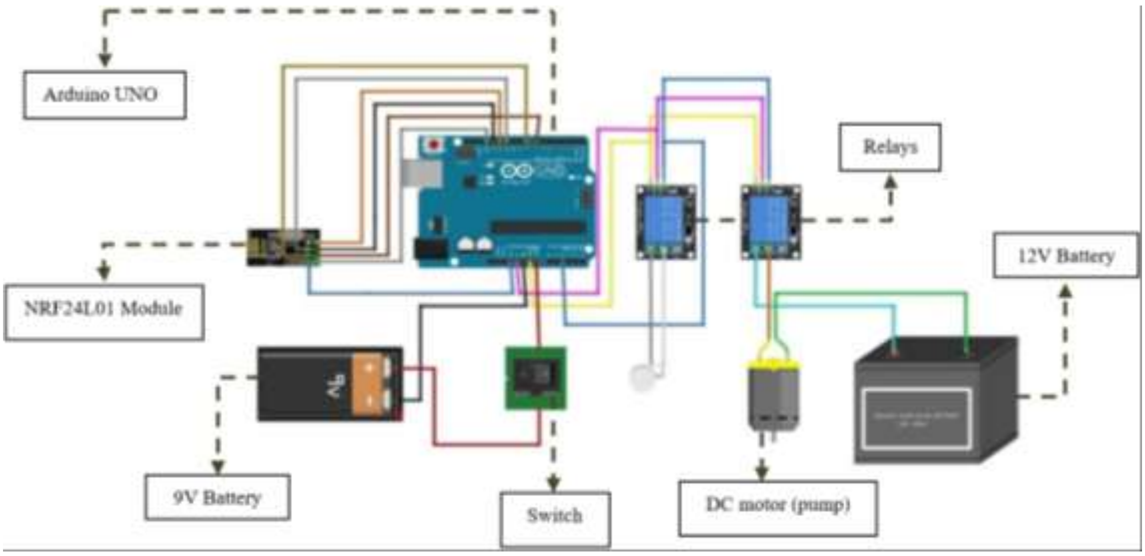

Figure 5. Receiver circuit

3.3. Validation and characterization

3.3.1. Length of the flames

The length of the flame produced by the flamethrower was investigated as a function of spray nozzle diameter, as in Figure 6. This parameter is critical for determining the maximum distance between the UAV and the HVTL. This determination of the maximum distance between the UAV and HVTL aims to the UAV's safety and preventing a UAV from approaching the transmission wire too closely. During data collection, the nozzle diameter is varied, and the length of the flame is measured using video analysis. Figure 7 shows the effect of the nozzle diameter on the length of the flame.

As presented in Figure 7, the larger the nozzle diameter, the longer the flame bursts. It is indicated that the greater the diameter, the more oil comes out of the spray tip. These results are consistent with earlier studies showing that the nozzle affects burst length [27]. By adjusting the diameter of this nozzle, the UAV can be placed at a safe distance from the transmission wire.

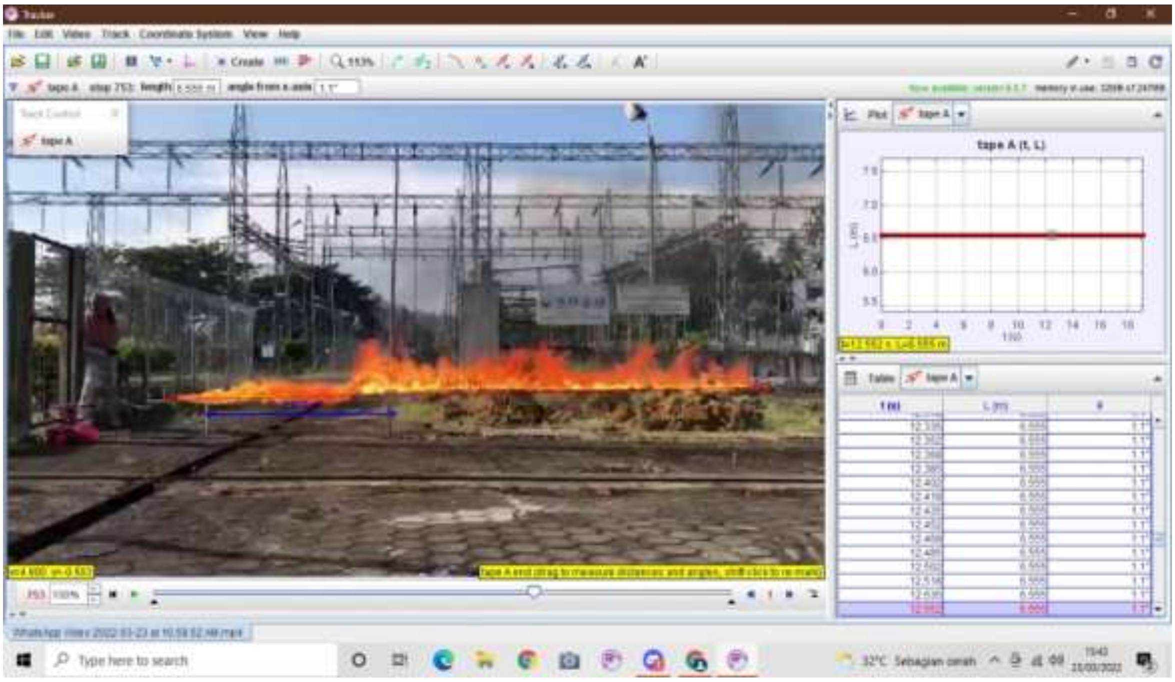

Figure 6. The process of taking data on the length of the flame

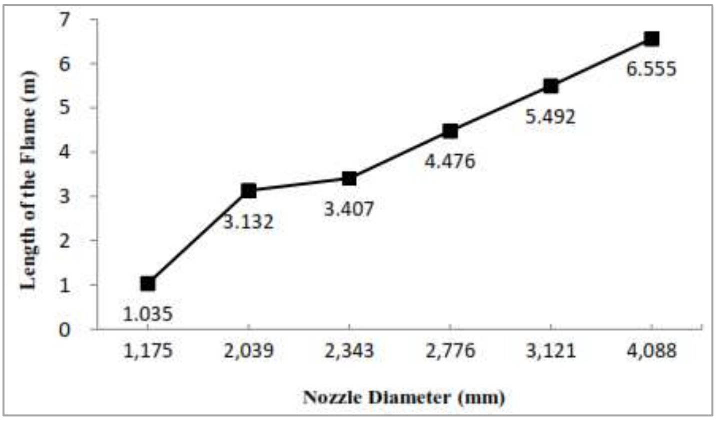

Figure 7. Effect of the nozzle diameter on the length of the flame

3.3.2. Kite burning time

This research also investigated how long it takes to burn a kite. The burn time is critical because it determines the flight duration of the UAV. In this experiment, a 47×50 cm kite using as a burning target, as in Figure 8. The data has collected by calculating the percentage of burned kites over time. Calculations are performed using video analysis based on a recording of the combustion process. The percentage of kites burned over time is shown in Table 3.

As presented in Table 3, it takes 5 seconds to completely burn a 47×50 cm kite. Based on the information, the time required to burn a larger or smaller kite, can be estimated. In addition, this data shows that the time required is very small, implying that the duration of the UAV flight is very short.

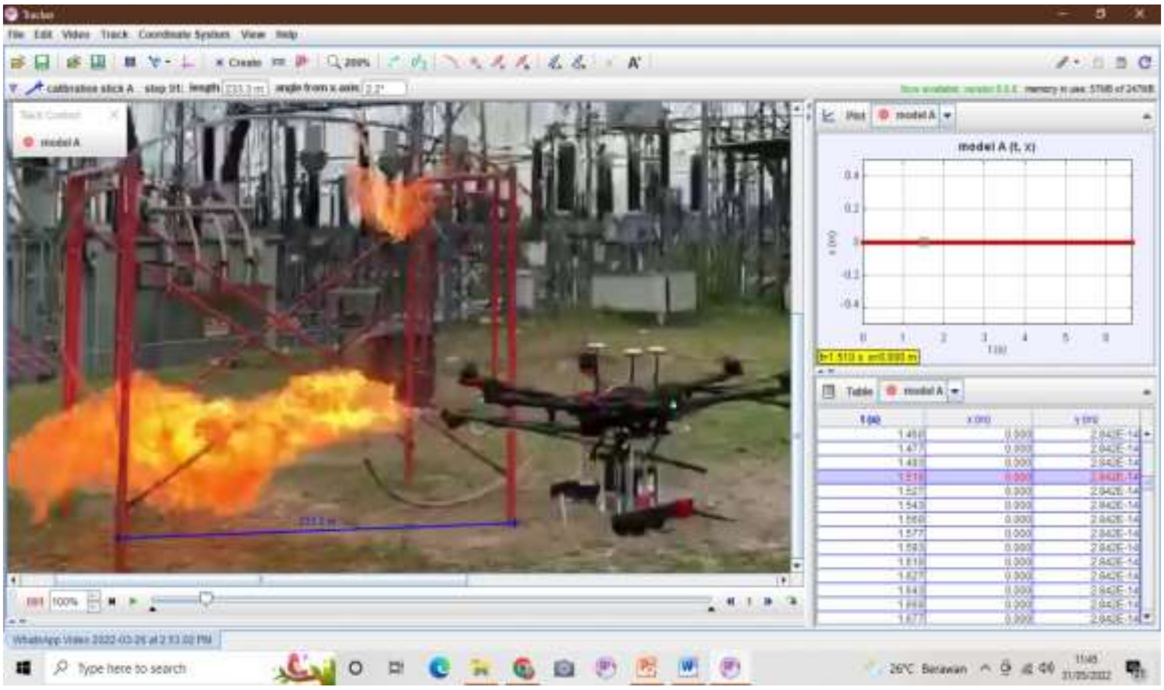

Figure 8. The process of taking data on the kite burning time

Table 3. Time it takes to burn a kite

Times (s)	Burn (%)
0,510	0%
1,010	30%
1,510	50%
2,010	70%
2,510	80%
3,010	90%
3,510	95%
4,010	97%
4,510	98%
5,010	100%

4. CONCLUSION

The function and operation of the transmitter and receiver circuits are to send and receive command signals to spit fire so that the data of the length of fire bursts and the time it takes to burn a kite can reveal the results of the performance specifications of the Arduino-based flamethrower system. The NRF24L01 module in the transmitter and receiver circuits has a 40-meter communication range. An Arduino-based flamethrower design criteria yield precision and accuracy.

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