Original Research Paper

Mobile Disinfectant Spraying Robot and its Implementation Components for Virus Outbreak: Case Study of COVID-19

Eze Val Hyginus Udoka[1,2*], Enerst Edozie[1], Musika Davis[1], Twijuke Dickens[1], Wantimba Janat[1], Okafor O. Wisdom[3], Kalyankolo Umaru[4], Ritah Nafuna[4], Nansukusa Yudaya[4]

[1] *Department of Electrical, Telecommunication, and Computer Engineering, Kampala International University. Uganda.*
[2] *Department of Publication and Extension, Kampala International University. Uganda.*
[3] *Department of Electronic Engineering, University of Nigeria. Nsukka, Nigeria.*
[4] *Department of Computer Science and Electrical Engineering, Muni University. Uganda.*

Article History
Received:
19.06.2023

Revised:
18.07.2023

Accepted:
28.07.2023

***Corresponding Author:**
Eze Val Hyginus Udoka
Email:
ezehyginusudoka@gmail.com

Abstract: The virus pandemic COVID-19 outbreak brought a huge pressure to the public healthcare system worldwide, especially in developing African countries like Uganda. The Educational system and institutions were put on a standstill due to no quick countermeasures to make the environment clean and safe for normal activities to continue. This paper successfully and comprehensively reviewed the Bluetooth and smart disinfectant spraying robot that successfully controlled the spread of the deadly virus. It also detailed different components that made up the complete spraying robot systems and from this it was observed that spraying robot systems are made up of almost the same components for implementations but differs on program that is embedded on the microcontroller due to different functions. This programing differs based on the functions that the designer/programmer wants the robot to do despite using almost the same components. This research review paper will act as guide for future researchers when designing and implementing a mobile spraying robot.

Keywords: Bluetooth, COVID-19, Disinfectant, Pandemic, Robot.

1. Introduction

The worldwide 2019 pandemic outbreak of novel coronavirus disease (COVID-19) and Ebola which brought huge pressure to the public healthcare and institutional system especially in developing countries in Africa like Uganda, Nigeria and so on. The COVID-19 pandemic had a serious impact on the business organizations and human lives and lead to worldwide lockdown. The governments and medical department did not have any specific plan and medical support to control the pandemic at the early stage.

According to World Health Organization (WHO), between January 2020 and January 2023 there has been over 769,201,169 COVID-19 cases recorded globally, including over 6,893,190 deaths with Uganda recording over 170,491 cases and 3,632 deaths [1]. At this stage, there was no specific cure in sight and mass vaccination coverage being less due to supply constraints and virus variants. Furthermore, one of the key measures to control the spread of COVID-19 and other contagious diseases was to prevent people from getting infected by using all the necessary precautive measures. Precautive measure was one of the effective measures used during COVID-19 pandemic such as social distancing, use of sanitizer, spray of disinfectants, use of nose mask and many more.

Furthermore, COVID-19 spread can be prevented technologically by developing and deploying robotic assistance systems in COVID-19 hospitals to overcome the induced difficulties and close contact. During the previous years, various robots were employed to conduct a series of key tasks and vital functions via different methods. It was found out that robotic systems were overall apt solutions for dealing with many problems caused by COVID-19. These included diagnosis, screening, disinfection, surgery, tele-healthcare, logistics, manufacturing, and broader interpersonal problems that were associated with pandemic lockdowns such as hospitals, airports, hotels and communities. Robotic systems had their own potential and advantage in the campaign against COVID-19. This was so effective because robots were immune to pathogens, they could easily access places humans have difficulties accessing because of their physiological makeups.

According to the Ministry of Health, an individual could get infected if he touches a surface that was contaminated with the COVID-19 virus and then touched his eyes, nose and/or mouth. Symptoms would begin one or fourteen days after exposure to the virus. According to the scientific study of the life span of COVID-19 virus, viruses in respiratory droplets and aerosols had a half-life of just over an hour but some could survive for three or more hours. The infectious virus could be detected on copper surfaces for up to four hours, on cardboard for up to 24 hours, and on plastic and stainless steel for at least 72 hours [2].

The chances of surface contaminations in a public institutions and hospitals were very high hence increased the risk of spreading the virus. Hence, washing of hands or use of hand sanitizers would get very hectic as one could be required to do so at every single turn. Introducing robotic disinfectant sprayers was to help close this gap within the campus premises hence reducing the risks of infection among the students and the stuff.

This research work mainly focused on indoor disinfection, as the COVID-19 virus could survive on the inorganic surface for up to several days or even weeks, depending on what kind of material it founds itself. This could cause healthy persons to get infected in addition to human-to-human proximity contact transmission. During that period, most of the indoor disinfection in the contaminated areas like hospitals and quarantine areas were done by a healthy worker becoming exposed to the virus. The educational system and institutions went through a tough time in order to maintain the educational activities due to the partial lockdown. However, after the lockdown was lifted for schools and institutions of higher learning to resume, some institutions and public places were faced with the need to keep the environment safe for the students and the staff. Therefore, a Bluetooth controlled robotic system that will disinfect objects and fumigate the environments is necessary for effective prevention.

2. Literature Review

Bluetooth-controlled spraying robots have gained significant attention due to their potential for efficient and precise spraying in various fields such as agriculture, pest control, and industrial cleaning. A study was published that focused on developing a Bluetooth-controlled spraying robot for pest control in a greenhouse. The robot was equipped with a spraying nozzle, a Bluetooth module, and a camera for obstacle detection. The operator could control the robot's movements and spray application through a Bluetooth-enabled mobile device [3].

In [4], a wireless remote controlled robotic vehicle was designed with a battery to satisfy power requirement. On this vehicle, a robotic arm was fitted along with a nozzle for sanitizer spray. A sanitizer storage tank was mounted on top to provide sufficient sanitizer for spraying. The robot was driven by an operator through a wireless remote control. An improved system was designed with many more features like obstacle realization, locations, direction, and navigation in the environment using different types of sensors. Figure 1 is the block diagram of the control hardware and power supply connections.

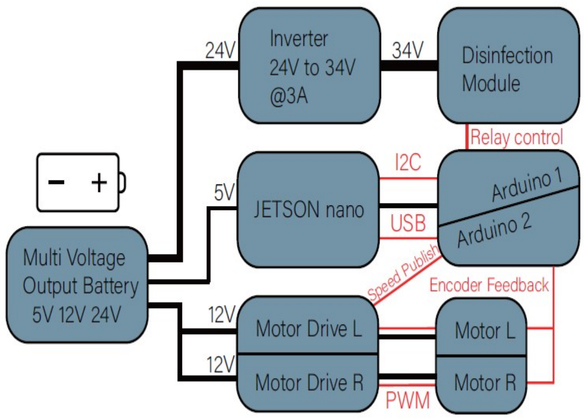

Figure 1. Block Diagram of the Connection between Control Hardware and Power Supply

The core of the control system was the upper-level controller (or master controller). Embedded control board (model: JETSON Nano, from NVidia Corp., Santa Clara, CA, USA) was adopted and programmed on the basis of Robot Operating System (ROS) to handle all of the input and output operations. Typical input included the data of surrounding distance from the lidar which detects obstacles in the nearby environment to avoid possible collisions. This uses sensor to detect obstacle within the environment and that makes it more effective and efficient.

A smart cleaner for an autonomous disinfection robot system for extensive disinfection applications was designed and developed by [5]. The robot structure consisted of the autonomous moving platform and the disinfection module. The autonomous moving platform was used to carry the disinfection module for navigation in the designated environment based on simultaneous localization and mapping (SLAM). The disinfection module was realized by an ultrasonic atomizer, which was able to convert hydrogen peroxide liquid into micrometer-sized dry mist for efficient space disinfection. For realizing obstacle avoidance, localization, motion planning, and navigation mobile robot perception was conducted by detecting recognizable features of the environment using different types of sensors. Robot vision and laser scanners were used. In that way, the meaningful elements (e.g., objects and scenes) in the environment could be detected for complete knowledge of the environment for carrying out the movement safely and reliably.

In Automated Hybrid Smart Door Control System [6], Design and Implementation of a Smart Surveillance Secuirty System [7], Design And Implementation Of Fire Prevention And Control System Using Atmega328p Microcontroller [8], Design and Implementation of an Improved Automatic DC Motor Speed Control Systems Using Microcontroller [9], A Review on Causes And Preventive Measures Of Fire Outbreak In Africa [10], Design And Implementation Of An Industrial Heat Detector And Cooling System Using Raspberry Pi [11], Effect Of Input Current And The Receiver-Transmitter Distance On The Voltage Detected By Infrared Receiver [12], Development Of Aduino Based Software For Water Pumping Irrigation System [13] and A Study of Cyber Security Threats, Challenges in Different Fields and its Prospective Solutions [14] were extensively reviewed and they used microcontroller bluetooth and aurduino to control their designed systems. These research articles [14] – [22] used microcontroller, bluetooth, infrared, ATMEGA 328p, Raspberry Pi and ardunio to design and implememt several wireless systems. These researchers effectively and successfully designed and implemented a user-friendly system at a vey low cost.

The following are the major components that were generally used in designing and implementing of a mobile disinfectant robot. The components of mobile disinfectant robot and its functions together with detailed connections are reviewed in this subsection [15] – [25].

2.1. Atmega328p Microcontroller

This is a high performance, low power controller 8-bit AVR microcontroller that is able to achieve the most single clock cycle execution of 131 powerful instructions. It is based on AVR RISC architecture. Figure 2 is the ATMEGA328P Microcontroller and its Pinout Configurations.

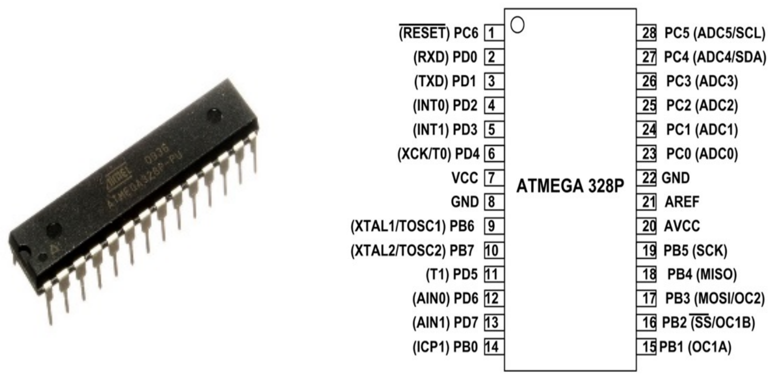

Figure 2. ATMEGA328P Microcontroller

The 28-pin ATMEGA328P chip with its pin configurations and descriptions. Many pins of the chip have more than one function and functions of each pin are described in as shown in Table 1.

Table 1. ATMEGA328P Pin-Out Functions and Description

Pin No	Pin Name	Description	Function
1	PC6 (RESET)	Pin 6 of PORT C	By default, it is used as RESET pin. PC 6 can only be used as I/O pin when RSTDISBL Fuse is programmed
2	PD0 (RXD)	Pin 0 of PORT D	RXD (Data Input Pin for USART) USART Serial Communication Interface (Can be used for programming)
3	PD1 (TXD)	Pin 1 of PORT D	TXD (Data Output Pin for USART), USART Serial Communication Interface (Can be used for programming) INT2 (External Interrupt 2 Input)
4	PD2 (INT0)	Pin 2 of PORT D	External Interrupt source 0
5	PD3 (INT1/OC2B)	Pin 3 of PORTD	External Interrupt source1 OC2B (PWM - Timer/Counter2 Output Compare Match B Output)
6	PD4 (XCK/T0)	Pin 3 of PORTD	T0 (Timer0 External Counter Input) XCK (USART External Clock I/O)
7	VCC		Connected to positive voltage
8	GND		Connected to ground
9	PB6 (XTAL1/TOSC1)	Pin 6 of PORTB	XTAL1 (Chip Clock Oscillator pin 1 or External clock input) TOSC1 (Timer Oscillator pin 1)
10	PB7 (XTAL2/TOSC2)	Pin 7 of PORTB	XTAL2 (Chip Clock Oscillator pin 2) TOSC2 (Timer Oscillator pin 2)
12	PD6 (AIN0/OC0A)	Pin 6 of PORTD	AIN0(Analog Comparator Positive I/P) OC0A (PWM - Timer/Counter0 Output Compare Match an Output)

Pin No	Pin Name	Description	Function
13	PD7 (AIN1)	Pin 7 of PORTD	AIN1(Analog Comparator Negative I/P)
14	PB0 (ICP1/CLKO)	Pin 0 of PORTB	ICP1 (Timer/Counter1 Input Capture Pin) CLKO (Divided System Clock. The divided system clock can be output on the PB0 pin)
15	PB1 (OC1A)	Pin 1 of PORTB	OC1A (Timer/Counter1 Output Compare Match an Output)
16	PB2 (SS/OC1B)	Pin 2 of PORTB	SS (SPI Slave Select Input). This pin is low when controller acts as slave. (Serial Peripheral Interface (SPI) for programming) OC1B (Timer/Counter1 Output Compare Match B Output)
17	PB3 (MOSI/OC2A)	Pin 3 of PORTB	MOSI (Master Output Slave Input). When controller acts as slave, the data is received by this pin. (Serial Peripheral Interface (SPI) for programming) OC2 (Timer/Counter2 Output Compare Match Output)
18	PB4 (MISO)	Pin 4 of PORTB	MISO (Master Input Slave Output). When controller acts as slave, the data is sent to master by this controller through this pin. (Serial Peripheral Interface (SPI) for programming)
19	PB5 (SCK)	Pin 5 of PORTB	SCK (SPI Bus Serial Clock). This is the clock shared between this controller and other system for accurate data transfer. (Serial Peripheral Interface (SPI) for programming)
20	AVCC		Power for Internal ADC Converter
21	AREF		Analog Reference Pin for ADC
22	GND		GROUND
23	PC0 (ADC0)	Pin 0 of PORTC	ADC0 (ADC Input Channel 0)
24	PC1 (ADC1)	Pin 1 of PORTC	ADC1 (ADC Input Channel 1)
25	PC2 (ADC2)	Pin 2 of PORTC	ADC2 (ADC Input Channel 2)
26	PC3 (ADC3)	Pin 3 of PORTC	ADC3 (ADC Input Channel 3)
27	PC4 (ADC4/SDA)	Pin 4 of PORTC	ADC4 (ADC Input Channel 4) SDA (Two-wire Serial Bus Data Input/output Line)
28	PC5 (ADC5/SCL)	Pin 5 of PORTC	ADC5 (ADC Input Channel 5) SCL (Two-wire Serial Bus Clock Line)

2.2. Hc-05 Bluetooth Module

Figure 3 is the HC-05 Bluetooth module that establishes a wireless network. The operating frequency of the module is 2.4GHZ, and the operating voltage is 3.3v. The device has two modes of operation which are; the data mode and command mode. The Command mode is used to operate the device while the data mode is used to transfer data between the devices [16-21]. This Bluetooth module covers a range <100m which depends upon the transmitter, receiver, atmospheric, geographic and urban conditions. It uses Frequency-Hoping Spread Spectrum (FHSS) radio technology to send data over the air and serial communication to communicate with devices. It communicates with the microcontroller using serial port UASRT.

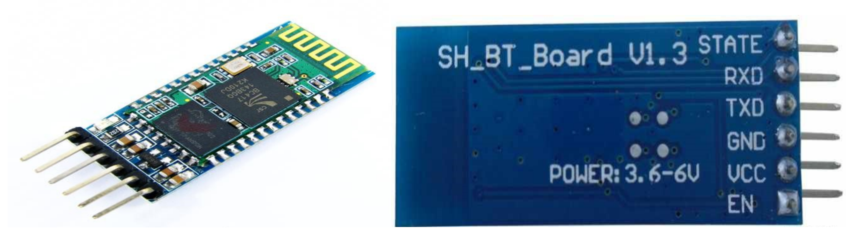

Figure 3. HC-05 Bluetooth Module

Table 2 is the HC-05 Bluetooth module PIN descriptions and their function.

Table 2. Bluetooth Module PIN Descriptions

S/N	Pin	Function and Descriptions
1	EN	It is used to bring Bluetooth module in AT commands mode. If EN pin is set to HIGH, then this module will work in command mode and by default it is data mode (exchange of data between devices)
2	VCC	Connect 5V or 3.3V to this Pin
3	GND	Ground pin of the module
4	TXD	Transmit Serial Data (wirelessly received data by Bluetooth module transmitted out serially on TXD pin).
5	RXD	Receive data serially (received data will be transmitted wirelessly by Bluetooth module).
6	STATE	It tells whether module is connected or not

2.3. Relay Module

A relay is an electromagnetic switch that opens and closes circuits electronically. It is an automatic switch that is commonly used in an automatic control circuit to control a high-current using a low-current signal. The input voltage of the relay signal ranges from 0 to 5V. Relays work like some electrical products since they receive an electrical signal and send the signal to other equipment by turning the switch ON and OFF. Its state changes only when electrical current is applied to the contacts [22-25].

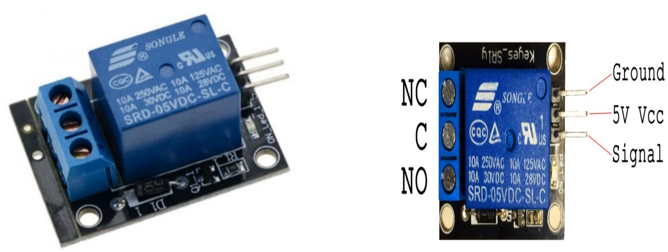

Figure 4. Relay Module

2.4. Motor driver

A DC Motor Driver is a rotating electro-mechanical device that turns electrical energy into mechanical energy. When DC voltage is applied to the motor terminals, an inductor generates a magnetic field that creates rotary motion [11] [15]. The L298N motor driver circuit is as shown in Figure 5 which is one of the hardware to be used in this design.

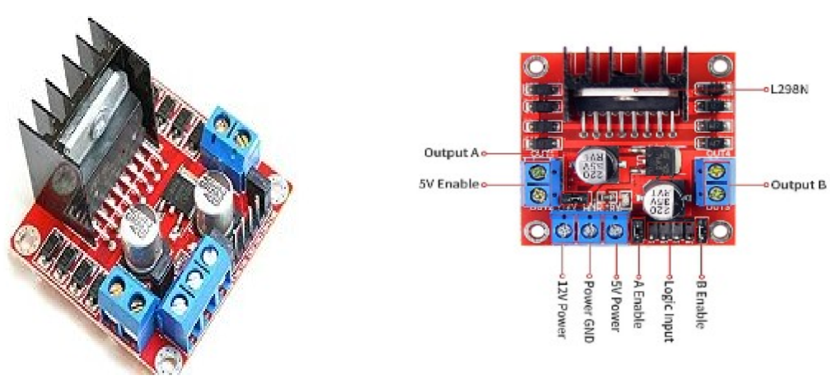

Figure 5. L298N Motor Driver

2.5. Voltage Submersible Pump

Figure 6 is the small water pump known as submersible, runs 0-12V DC and can move about 120 liters per hour with low current consumption of about 220mA.

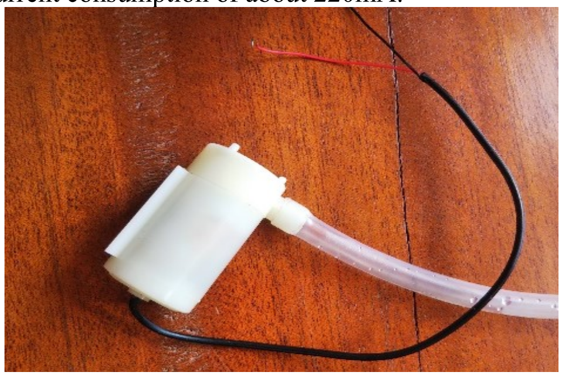

Figure 6. Submergible Pump

2.6. Battery

The robotic system will be powered by two 3.7V Li-ion rechargeable batteries which will serve as the main power supply for the robotic unit. The 3.7 Li-ion battery is as shwn in Figure 7.

Figure 7. 3.7V Rechargeable Batteries

2.7. Three-Wheel Drive Robot Car Chassis

Three-The frame is made up of 3mm plastic like sheet with a dimension of 540mm length and 145mm width. The frame acts as a base and is used to assemble almost all the components. Figure 8 is the three-wheel car base that will be used for locomotion and as well as the base for all the components to be fixed. It is fixed with two dc motors that rotate the wheels when a certain voltage is applied to the system heel Drive Robot Car Chassis.

Figure 8. 3WD Smart Robot Car Chassis

2.8. DC Gear Motor

A DC Motor Driver is a rotating electro-mechanical device that turns electrical energy into mechanical energy. Hence, when the DC voltage is applied to the motor terminals, an inductor generates a magnetic field that creates rotary motion. Inside the electronic motor is an iron shaft wrapped in a coil of wire as shown in Figure 9. This shaft contains two fixed, North and South, magnets on either side and the magnets cause both a repulsive and attractive force, in turn producing a torque.

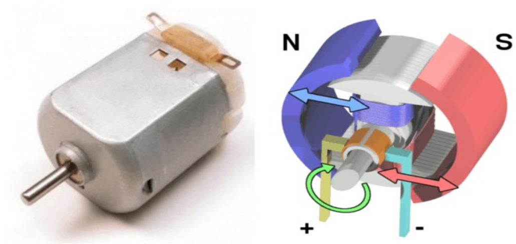

Figure 9. DC Motor

2.9. DC Gear Motor Fixed on a Robot Wheel

A Gear motor is an all-in-one combination of a motor and gearbox. The addition of a gearbox to a motor reduces the speed while increasing the torque output. The DC gear motor fixed on a robot wheel is as shown in Figure 10. The device has two modes of operation known as data mode and command mode. The Command mode is used to operate he device while he data mode is used to transfer data between the devices.

Figure 10. A DC Gear Motor Fixed on a Robot Wheel

3. Methodology

This research reviewed 15 related articles in robotics implementation and design and inference on essential components that made up a water spraying robot was drawn. This paper systematically and analytically reviewed all the major components that are need for the design and implementation of spraying robots by reading different related papers and some practical works done at the Kampala International University electrical, telecommunication and renewable energy lab situated in Uganda.

4. Finding and Discussion

This extensive and detailed review of the components and possible connections of a disinfectant spraying robot showed that the designs have almost the same components but with different pattern of design and programming depending on the specific task that the robot needs to perform.

5. Conclusion

This paper successfully and comprehensively reviewed the Bluetooth and smart disinfectant spraying robot. It also reviewed different components that made up the complete spraying robot system. From this review, it was observed that spraying robot systems needs almost the same components for implementations but differ on programs that are embedded on the microcontroller. This programing differs based on the functions that the designer/programmer wants the robot to do despite using almost the same components. This review paper will act as guide and template for future researcher that will like to venture in designing and implementation of mobile spraying robot as all the necessary connections and components needed for it were reviewed in detail.

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