Arduino Controlled Hospital Sanitization Robot Vehicle

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Abstract

The outbreak of the COVID-19 pandemic has made it necessary for all to follow social distancing, wear masks, and sanitize regularly. As of now, the human workforce is required to sanitize the hospitals and is considered as one of the challenging tasks due to the high risk of contraction. Hence, it is important to reduce human involvement and bring in robotic systems for such requirements. Utilizing robots not only decreases the risk of spreading the coronavirus but also ensures no other harmful pathogens can transfer between humans. As medical workers are more exposed to this virus and are at greater risk of contracting it, these robots can be used instead for sanitizing the rooms of the affected patients or of isolation wards. In the paper, a prototype of a Hospital Sanitization Robot Vehicle (HSRV) using Arduino is presented that can help the hospital staff to sanitize any part of the hospital through a remote-control mechanism without putting their lives in danger. The robotic model can not only be used in hospitals but also at homes, COVID care centers, and quarantine centers where symptomatic or asymptomatic people are under isolation.

Keywords
Arduino, COVID-19, DC Pump, Disinfectant Liquid Storage, HSRV.

1. Introduction

On 31st December 2019, a new variant of the disease, coronavirus, was identified with a different kind of pneumonia in Wuhan city, China. Later WHO (World Health Organization) analysed the cause and in January 2020 named it as "2019-nCoV" (Ahmed and Gouda, 2020). The disease has since been spreading throughout the world until today. This new virus is accountable for the severe acute respiratory syndrome known as coronavirus disease. Total infected cases worldwide have reached 212,357,89 and about 4,439,843 million people have died as of 24 August 2021 (WHO, 2021). This virus can be transmitted easily through droplets containing the virus which come directly in contact with eyes, nostrils, or mouth. So, the governments are trying to contain it by suggesting people through various means such as maintain social distancing, wearing masks, isolating and, getting vaccinated (Shen et al., 2021). The vaccination drive worldwide has seen a rise reaching a total of 4,619,976,274 as of 22 August 2021 (WHO, 2021).

By using technology, people are placing robots to deal with the current pandemic situation so as to reduce the further spread of covid-19 disease person to person. Moreover, these robots will perform jobs from sanitizing hospitals to delivering foods, medicines, etc. thus minimizing human activity as much as possible (Auria and Persia, 2021). Using Artificial Intelligence and infrared sensors, a bond between robots and humans can be created helping robots to recognize humans and offer them mental help (Azeta et al., 2018; MOnarCH, 2018; Yun and Lee, 2014; Chaturvedi et al., 2016). Robots can be made to carry medical equipment and tools (Pervez-Videl et al., 2012; Begic, 2018; Guettari et al., 2021; Hasan et al., 2012) and can also help in reminding patients to take medicines (Bogue, 2017; Shishehgar et al., 2018; Pineau et al., 2003) and also can diagnose and monitor the vital functions of the patients

(Chivarov et al., 2015). For this, electromagnetic compatibility of the robot construction in operational condition is being explored (Kondratiuk et al., 2016; Kondratiuk et al., 2013; Kondratiuk et al., 2009).

2. Literature Review

A few medical robot research publications were surveyed, and the following references had an impact on the design of the smart medical aid robot. Zukowski M et al. (2018) have presented a humanoid medical assistant and companion robot exclusively for children's hospital. They concentrated on the robot's ability to express and interact with kids by identifying their features and telling stories and presenting instructional movies using visuals and text on the chest display. The 'Bobot' traverses through patient rooms on its own, performing simple diagnostic tests such as detecting a patient's body temperature or pulse rate and transmitting a live video feed to doctors and nurses. The Bobot acts as a companion for young patients.

Zukowski et al. (2018) have implemented patient's temperature measurement system for humanoid medical robotic assistant. They conducted experiments with the MLX90614 infrared thermometer and the FLIR Lepton thermal imager and found that the MLX90614 infrared thermometer cannot be used as the sole input source to the system, and for the most accurate results the robot must be close to less than 0.3 meters in front of the patient. To get the better of this, they made a hybrid framework having an infrared thermometer alongside a thermal camera to give surrounding temperature and estimated skin temperature that can be utilized to recognize the presence of people before the robot.

Chempolil et al. (2021) have developed a prototype using Arduino UNO that assists the hospital nurses. The primary focus of this model is to make the medical attendant not deal with the gadgets which were handled by the patients in which data can be passed through a sound framework or a medical attendant will help the underlying directions needed that is in the secluded ward so the patient can do the errand appropriately. With the help of a temperature sensor, they took readings and could supply power to UVC lamp that sterilized the items inside the rooms when exposed for 2 to 3 minutes.

Biswas et al. (2020) have presented an autonomous robot that accompanies the doctors and executes the given instructions. Using a distance sensor, the robot is made to be positioned at a sufficient distance from the doctor. It performs touchless operations using its automatic sanitization property. It also cleanses the necessary components using a UV sterilization system.

3. Methodology

Hospital Sanitization Robotic Vehicle (HSRV) is an android controlled system. Fig. 1 shows the block diagram of the prototype.

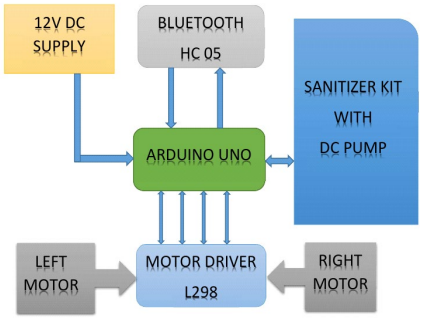

Figure 1. Block Diagram of HSRV

The Robot is mainly divided into two major sections namely:

- Control Section
- Sanitization Section

The control section is further divided into three blocks namely:

- Micro-controller block.

- Bluetooth block.
- Motor driver block.

3.1 Micro-controller Block

Arduino is an open-source prototyping platform that consist of both Hardware and software IDE which is used to upload the program code to the physical board.

Arduino Uno is a microcontroller board based on the ATmega328P Microchip. It has 14 digital i/o pins out of which 6 pins are used as PWM outputs, 6 as analog inputs, a 16 MHz ceramic resonator (to generate ATmega328P's clock signal), a power jack, an ICSP header, a USB connection, 2 or more inbuilt LED's and a reset button.

3.2 Bluetooth Block

The HC-05 is a full-duplex wireless module that is made to transfer data from mobile phones to the microcontroller. An android application is used to control the module wirelessly. Communication happens with the help of USART at 9600 baud rates, hence it is easy to interface with any microcontroller that supports USART (Serial communication).

The HC-05 has 6 pins namely

- Enable pin
- Vcc
- GND
- Tx and Rx
- Button switch
- State

3.3 Motor Driver Block

The Motor Driver L298N module is an integrated circuit chip that works as a motor controller. It assists the motor to move in any direction such as clock/anti clock as per user inputs (high and low). When input pins IN1 & IN3 are high motor rotates clockwise, similarly when they are low motor goes anti-clockwise and vice versa for IN2 & IN4 input pins. Enable pins helps in controlling the speed of the motors. The block also includes L298 IC, 78M05 Voltage Regulator, Power LED, 5V jumper, resistors, and capacitors.

3.4 Sanitization Section

The sanitization section consists of

- Disinfectant Liquid Storage with pipe
- DC Pump

a) **Disinfectant Liquid Storage with Pipe:** An arrangement of a vessel stored with liquid disinfectant (a liquid which is effective in preventing diseases caused due to bacteria and viruses by killing them) with a pipe connected to a DC pump.

b) **DC Pump:** Uses DC supply from the battery to spray liquid. The dc pump operates at different voltages for different applications. DC pump works based on centrifugal force to spray liquid disinfectant.

3.5 Flowchart

The operational flow of the HSRV is shown using two flowcharts. Fig. 2 shows the main loop flow and Fig. 3 shows the flow in the case of the remote-control mode.

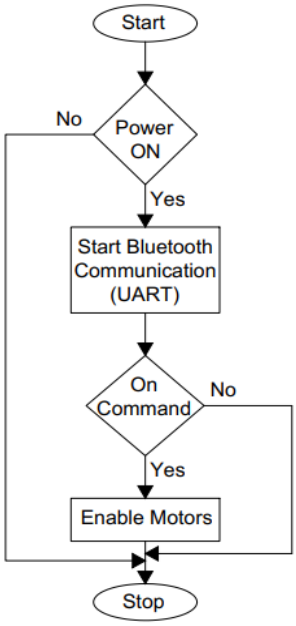

Figure 2. Flowchart of the Main Function

4. Results and Discussion

The sanitization section of the HSRV communicates to the Bluetooth of an android device such as a smartphone via a Bluetooth module (HC05), with the help of an android application. The corresponding commands are passed as input via Bluetooth to the robot. The Arduino on the robot checks the command received from the user and then Microcontroller will give inputs or instructions to the motor driver, hence the motor driver controls the DC motors based on the input received, this causes it to move forward, reverse, left, and right and in any angular direction.

The sanitization section can be set up manually by the user or automatically via Bluetooth. Thus, by this the robotic vehicle is made to move around the rooms or preferred environment to spray the liquid disinfectant and hence to sanitize and clean the hospital rooms without human contact. Fig. 4 shows the prototype from different views. Fig. 5 and Fig. 6 shows the side view and the top view of the HSRV.

The Arduino controlled Hospital Sanitization Robotic Vehicle was tested in a single room of area 800 sq. ft. (10 ft x 8 ft) using half a liter of the sanitizing liquid. It was observed that the robot could sanitize the entire area in a very short period of about two minutes and it could spray the liquid to a distance of about 1 m.

Table 1 shows the motor control logic utilized for controlling the movement of the robot vehicle. IN1 and IN2 operate right motors whereas IN3 and IN4 operate left motors. According to the position of these inputs the motors move in forward, reverse, left, and right directions.

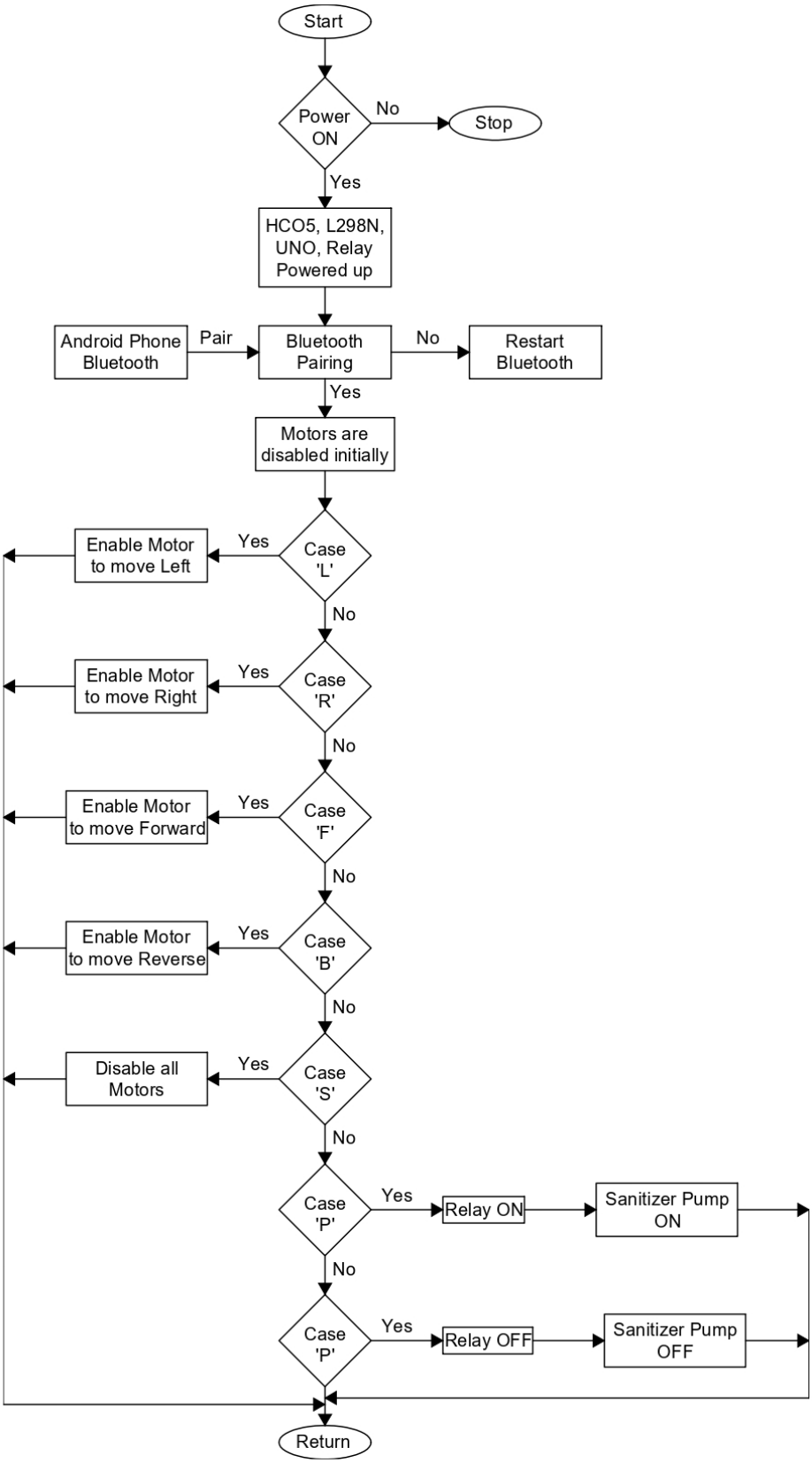

Figure 3. Flowchart of the Remote Control Mode

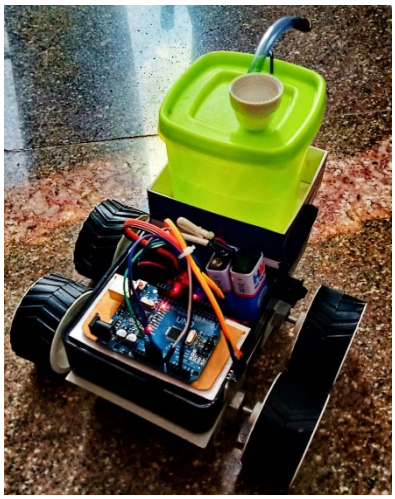

Figure 4. Prototype of HSRV

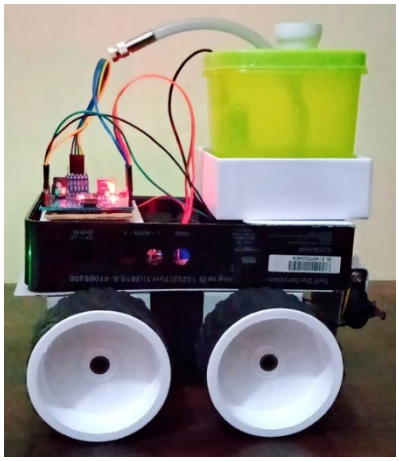

Figure 5. Side View of HSRV

Figure 6. Top View of HSRV

Table 1. Motor Control Logic for Movement of Motors

IN1	IN2	IN3	IN4	Directions
Right Motors		Left Motors		
1	0	1	0	Go Ahead
0	1	0	1	Move Back
1	0	0	1	Move to Right
0	1	1	0	Move to Left
0	0	0	0	Motors Off

The main objectives of the prototype are:

- To clean and make virus (infection) free Rooms by sanitizing via robots.
- Use of wireless technology for prevention of COVID-19 infections.
- Helps in the prevention of viral attack to humans.

Fig. 7 shows the remote-control screen consisting of the following buttons:

- For connection to the Bluetooth module.
- For the movement of the robot.
- For controlling (turn-on and turn-off) the pump motors.

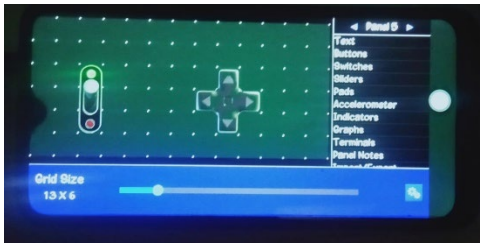

Figure 7. HSRV Application

4.1 Spraying Mechanism

The pumping motors are switched on using a 5 V programmable relay switch. The reservoir containing the sanitizing fluid is placed at the top of the robot with two number of 6 V immersion type pumps placed inside the container to pump the fluid to the sprayer. Fig. 8 shows the sanitizing liquid being sprayed from the nozzle.

Figure 8. Spraying of sanitizing fluid by the robot

5. Conclusion

Coronavirus disease (COVID) transmission can happen through respiratory beads and different entities and surfaces like toys, door handles, consoles, and so on. Vaccine for the infection has been rolled out and over 4.6 billion of doses have been administered up to 24 August 2021 as per the data released by the World Health Organization. Even though

the vaccines have shown robust antibody responses, there are cases of full-vaccinated individuals contracting it. Since it is a destructive infection, to diminish the spread of disease it is smarter to deploy robots instead of using humans.

In this paper, a prototype of Arduino controlled HSRV is presented. The prototype was tested successfully by remotely controlling it to sanitize a room without the need of the operator touching any of the objects located within the vicinity. The implementation of this prototype will prevent the spread of the deadly virus and ensures the safety of the lives of the frontline warriors.

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Biographies

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