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Design and Implementation of Surface Disinfection Robot Using UVC Light and Liquid Sanitizer

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***Abstract*—New general health problems jeopardize the globe with the growth and breakout of the 2019 novel coronavirus (2019-nCov) or the significant severe respiratory syndrome coronavirus 2 (SARS-Cov-2). The only way to reduce the spread of the virus is to maintain social distance and follow the rules set by our respective governments. However, manual disinfection is time-consuming, challenging, and poses safety dangers. Using robots for disinfection consequently becomes an appealing option. Furthermore, the robot can sanitize a location incredibly fast without exposing ourselves. So, in this research, we constructed a sanitization robot that would eliminate the coronavirus in the hospital and apartment building or elsewhere. In this study, we have developed an Arduino-based wireless robot where UVC Light and Liquid Sanitizer are utilized for eradicating the coronavirus. A servo motor, gear motors, wheels, and L298 motor driver module are employed for distinct purposes of the robot. Moreover, two mobile phones are used as IP Cameras for monitoring the robot. Thus, our robot can be employed for the sanitization procedure so that physical appearance will not be necessary.**

***Index Terms*—Corona Virus, Sanitization, Micro-controller, UV-light, Disinfection Robot**

I. Introduction

Since late 2019, the outbreak of the new coronavirus epidemic (COVID-19) has become a global pandemic, which causes significant strain to the public healthcare system worldwide. By 25 November 2021, there were 258,164,425 confirmed cases and 5,166,192 fatalities, with 662,163 daily rises in new cases recorded by World Health Organization [1]. With no miracle cure and universal vaccination coverage insight, because of supply limits and viral varieties, one of the crucial strategies to curb the spread of COVID-19 and other infectious illnesses is to prevent healthy people from being sick. For example, avoiding unnecessary interpersonal interactions, terminal disinfection, and isolation of infection are helpful approaches. Most nations have embraced such measures worldwide and have proven the intended impact in controlling the escalation of disease and asymptomatic infection cases. However, the absence of treatment, high fatality rates and the overall spread of this infection of COVID-19 need to develop an effective and easy strategy to prevent and stop. To avoid this imperfection, an innovative idea is necessary with less human cooperation to decrease the possibility of infection spreading. Amid this worldwide epidemic, stepping in where people should not, robots are being utilized for activities such as sterilizing hospitals and transporting food and medications and have shown to be beneficial and convenient. From a technological perspective, the deployment of robots is a part of the preventive strategy to overcome the induced challenges and enhance the effectiveness of battling the COVID-19 pandemic. Many robots have undertaken several critical duties and vital functions during the last year via diverse techniques [2]. Sanitization has become a significant component in these pandemic times and plays a critical role in keeping us from exposure to this deadly virus, so assisting in eradicating this worldwide pandemic is crucial. One of the high-risk zones of exposure to this fatal virus is in the areas where people rush for treatment, which are the hospitals and the medical wards. Sanitization in these locations is extremely tough and needs very high precautions to be followed. However, after economies reopen, public gathering locations such as airports, event sites, public transportation, transit stations, schools, markets, and workplaces also play a critical role in preventing diseases. Because frequently-touched surfaces such as doorknobs, handrails, elevator buttons, faucet handles, chairs, tables, Etc., are more likely to be contaminated. Using the UV disinfectant will help health officials lower the transmission in health care settings like hospitals as a critical area where patients congregated [3]. The usage of Robots in the sanitization process has provided a safer environment for humans. The report [4] tells about an office suite in North America being sterilized by installing permanent UV lights in various spots in the workplace. They claim to be one of the most hygienic areas in North America. UV is installed aiming at the ceiling to disinfect the air, and other UV lamps only turn on when no one is in the room. They suggest that this will assist in zapping microorganisms on keyboards, workstations, workplaces, and high-touch surfaces in restrooms. In paper [5], 34 scientific articles on diverse technical UV systems that have been created to decrease the spread of diseases were synthesized, out of which 21 percent of the articles are about public area disinfection. A study employing the evolution of technology to design and construct infrared thermal scanning using a camera is discussed in [6]. The research team [7] constructed a UV bot with three UV lights positioned on the top platform spanning 360° orientation. This bot is meant for sterilizing in an operating or a patient room. However, the robot needs an internet connection and operates through the webpage. Numerous techniques of infection spread and studies [8]–[11] have shown that the significant source of touch surface is coming from direct tough of door handles or cabinets, remote control, call button for support, Etc. [12]–[15]. Internet of Things, notably in health care and medical industries, has been viewed by many people due to its support in monitoring, regulating, and preventing pandemics [16]–[18]. This research aims to limit human involvement as much as possible, therefore automating the chores such as sanitization with robots. The primary contribution of this research is the design and development of a revolutionary, cost-effective autonomous disinfection robot system for large disinfection applications. In this situation, the deployment of robots may decrease human exposure to viruses, which has become more crucial as epidemics spreads. In this study, we used the Arduino development board to operate the system and the NRF24L01 module to communicate between the robot and the controlling device. Furthermore, the robot employs powerful UV lights and sprays liquid sanitizer, which may work against the COVID-19 virus.

II. Overview of the System

"Fig: 1" illustrates the graphical representation of the transmitter unit or our controller. The transmitter unit comprises one 2.4GHZ nRF24L01 module, pushbuttons, and a smartphone. nRF24L01 and push-button are attached as peripheral devices to a microcontroller (ATmega328p). The pushbuttons are used to control our robot. The nRF module is used in the transmitter portion, which sends data to the reception unit. A smartphone has been used to watch live streams captured through the IP camera.

The block diagram of the receiver unit is depicted in "Fig: 2". Here, we have another nRF module that receives the data from the transmitter unit. In this section, we employed a motor driver (L298) to operate our robot's wheel gear motors. It also contains a water pump attached to the Arduino through a relay module. It also features ultraviolet C (UVC) light and an IP camera (Smartphone) via which we can see the live stream on receiving mobile. Motor driver, Relay module, nRF24L01, and UVC light are attached to a microcontroller (ATmega328p) as

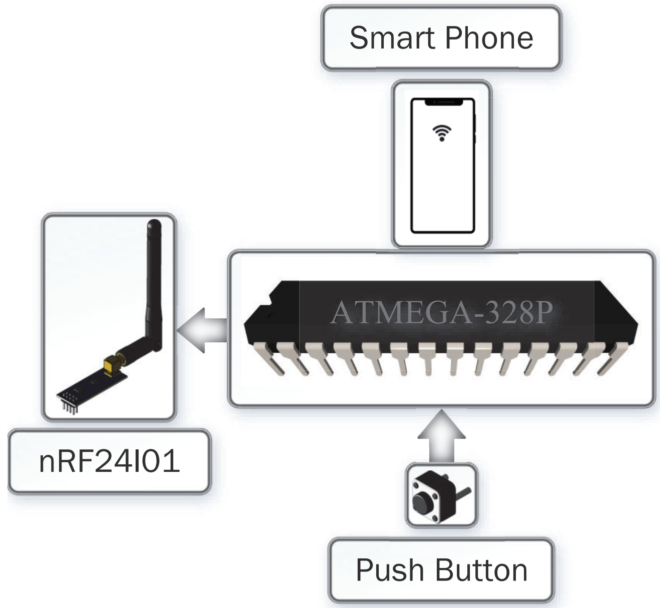


Fig. 1: Block Diagram of the Transmitter Section.

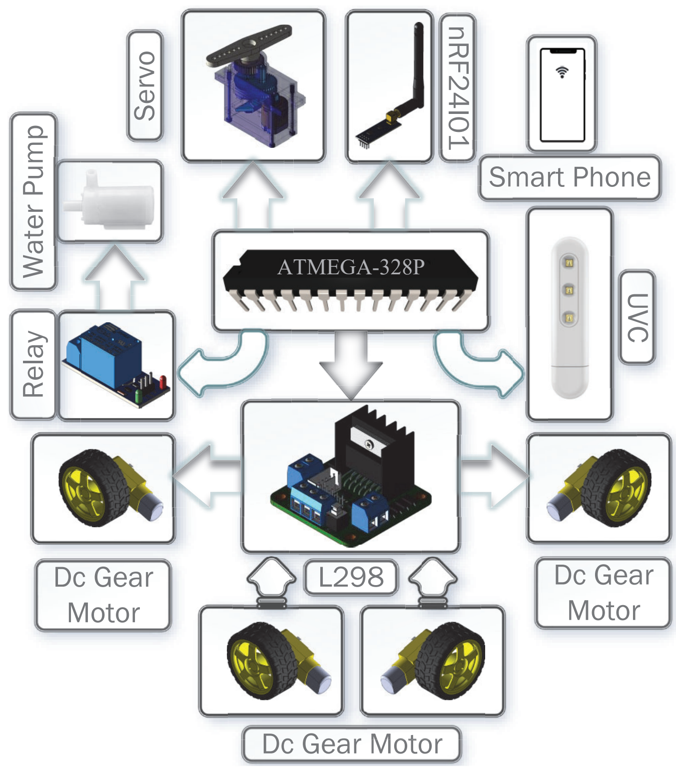


Fig. 2: Block Diagram of the Receiver Section.

peripheral devices.

III. Methodology

This section covers the approach used to construct the system prototype. This system is separated into two parts: the transmitting and receiving portions. Where the transmitter part is our controller and receiving section is our robot.

A. Transmitting Section

The transmitting portion, called the admin section, belongs to the owner or person operating the robot and monitoring it. As we can see from “Fig. 7”, there are several buttons, each of which is utilized for distinct functions. To drive the robot left, right, forward, backward, and stop, there are five pushbuttons, which we indicate in “fig. 7”. A button is used to regulate Ultraviolet C (UVC) light. Another switch was placed here to turn on and off the water pump. Two buttons are for shifting nozzles left and right to spray effortlessly. Each button does work according to the programs that we have specified. These buttons allow us to navigate the robot smoothly. For wireless remote communication, there is an nRF24L01 that transmits data toward the receiving device. nRF24L01 is a wireless transceiver module (runs on SPI Interface). This nRF is utilized here as a transmitter. It has a 2.4 GHz frequency, and its range is approximately 1 kilometer, which is adequate for us. So, at a distance of 1 kilometer, we can effectively control our robot. However, it is tough to see what is occurring in front of the robot and sanitize someone if the robot is not close. So, we have implemented an IP camera (Smartphone) in our study for monitoring reasons. We also utilize a smartphone in the transmitting unit to display its output. With this, we can easily see live data and operate our robot according to our demands. These components are linked to the microcontroller I/O pins, also via MOSI, MISO, and SCK.

B. Receiving Section

The receiving portion, designated as the public section, belongs to the public or those who need to be sanitized. From “Fig. 8”, we can see an nRF24L01, which operates as a receiver and receives data from the transmitting unit. Four DC gear motors are employed to move the robot. These four motors are coupled to the L298 motor driver. A relay module is used to operate a dc water pump. The water pump is employed to pump up the liquid sanitizer from the sanitizer chamber. Here we used a servo motor to operate the pump nozzle so that one may be conveniently sanitized by it. The servo motor enables the nozzle to move left and right quickly, controlled by the admin section. We have employed some UVC lights parallelly linked to each other and connected their two terminals with a relay. All these components are linked to the microcontroller’s I/O ports. We have also used MOSI, MISO, and SCK PIN for nRF.

C. Circuit Diagram of the system

The simplified circuit diagram of the transmitter and receiver circuit is provided in ”Fig. 3” and ”Fig. 4” accordingly.

The goal of the transmitter circuit is to monitor whether any push-button is pushed. If any push button is pushed, it will transfer the information to the receiver circuit. The ATmega328P microcontroller is incorporated in this design. It is a 10-bit microcontroller with 14 digital I/O pins and 6 analog pins. The interconnections of multiple peripheral devices, such as the nRF transmitter module and 9 push-button with the microcontroller, are depicted in ”Fig. 3”. An ATmega328P also utilized in the receiving circuit. The desired features of the microcontroller for the receiver circuit are digital I/O pins to interface relay, PWM pin to attach motor driver, MISO, MOSI, SCK, CSN, CE pins to interface nRF module. All the connections of the components in the receiver circuit are represented in ”Fig. 4”. It should also be indicated in the prototype.

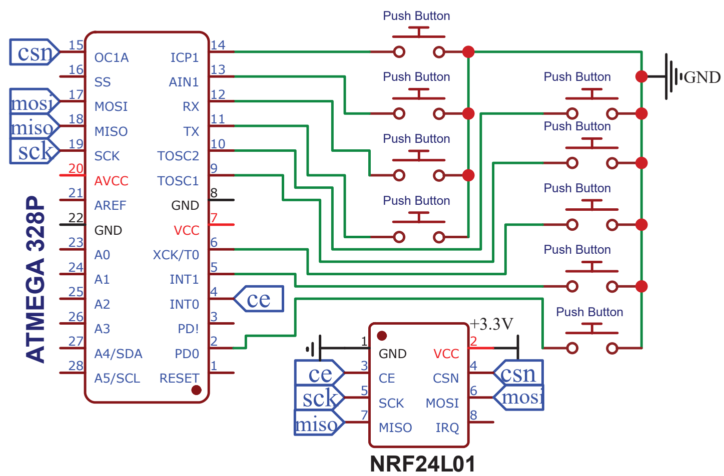


Fig. 3: Circuit Diagram of Transmitter Section.

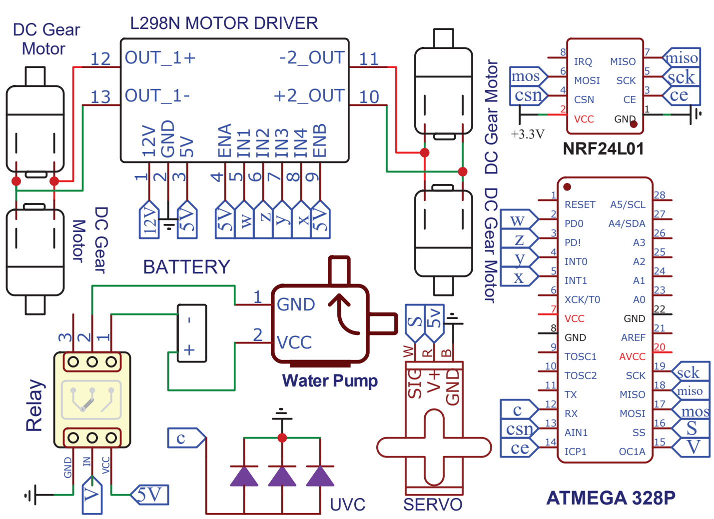


Fig. 4: Circuit Diagram of Receiver Section.

IV. Programming, Implementation & Result

A. Flowchart

"Fig. 5" and "Fig. 6" respectively depict the program's flowchart uploaded into the microcontroller for both the transmitter and receiver circuits. The programs are developed at ARDUINO IDE software. In the fundamental framework of the program, there are two functions: void setup() and void loop(). The commands are written in void setup() runs just one time. However, on the other hand, the commands are written in a void loop() continually executed by the microcontroller.

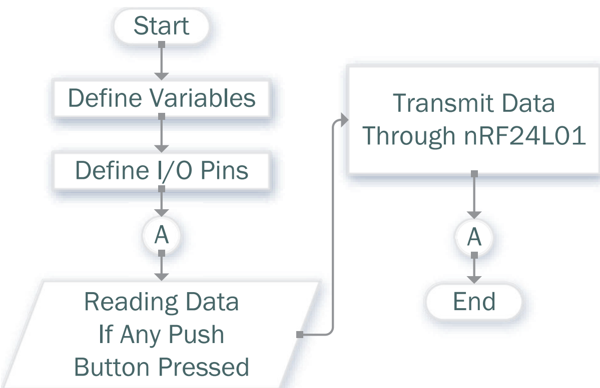


Fig. 5: Flowchart of the code that has been put into the microcontroller (Transmitter).

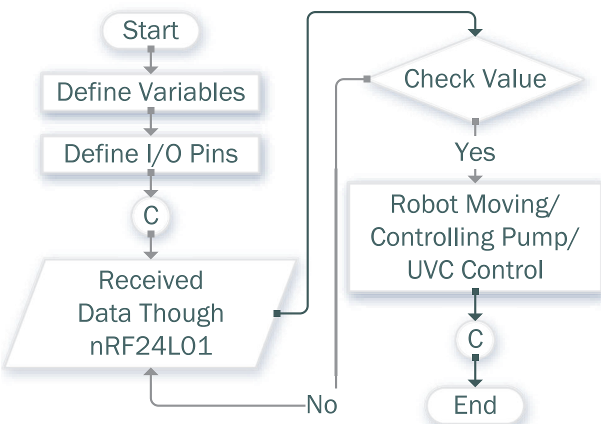


Fig. 6: Flowchart of the code that has been put into the microcontroller (Receiver).

In "Fig. 5", it shows that the transmitter unit's microcontroller continually reads whether any button from the controller is pushed and sends it to the receiver microcontroller using the nRF transmitter. Finally, in "Fig. 6", we can see that after receiving the data from the transmitter, the receiver microcontroller will verify the value and perform the relevant instruction. If the value is addressed and transmitted correctly, then the sanitization procedure and movement of the robot will be resumed, otherwise not.

B. Result & Analysis

The system is developed and tested, and some prototype photographs are presented in "Fig. 7" and "Fig. 8". The NRF module and Microcontroller are integrated on Veroboard in the transmitter and reception section. All other equipment is respectively arranged on the wooden board as the prototype. Since the equipment's situated in such a manner, it may be either detached or installed if they are to be changed. The nRF24L01 of the transmission portion transfers the data to receiving component.

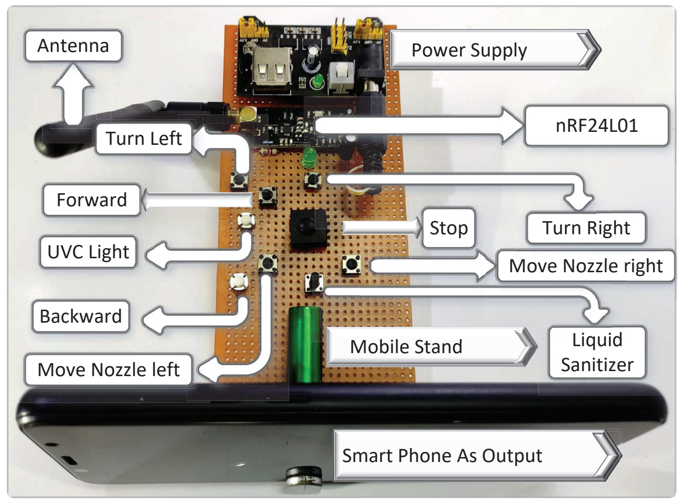
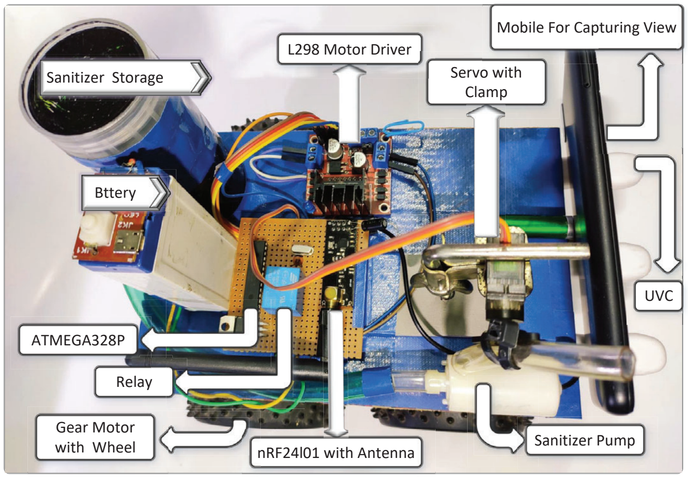
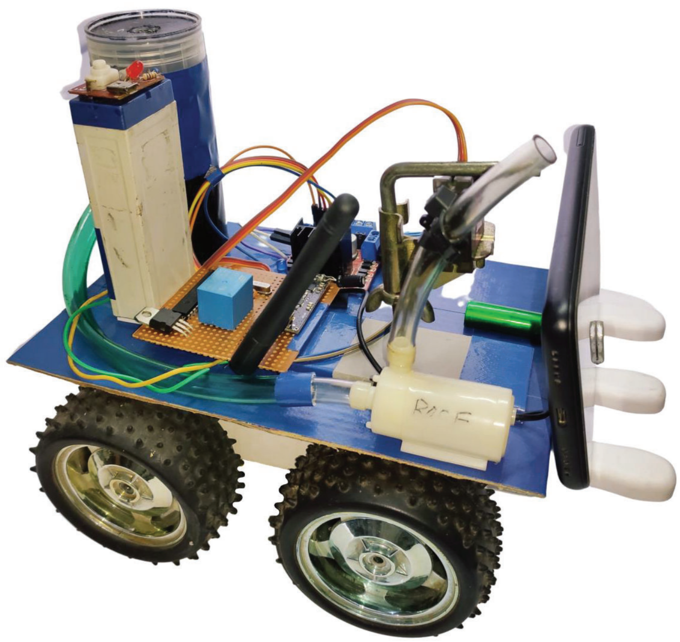


Fig. 7: Complete Overview of the Transmitter section.

From "Fig. 7," we can see that there are 5 switches used to regulate DC motors to move the robot forward, backward, right, left, and stop it. One button is to on/off the UVC light. One button is to shift the nozzle of the sanitizer right, and another one is for the left. The last one is to turn on the water pump to spray liquid sanitizer from the tank. Here, in the receiving portion, we have used a smartphone as our IP camera to capture the video in front of our robot, which will assist us in managing our robot efficiently. Furthermore, in the transmitting unit, we have used another Smartphone to see the live stream. Both mobiles are connected using software named "IP webcam." We can utilize any smart device like mobile, laptop, tab, etc., for monitoring purposes. An SMPS (Switch Mode Power Supply) device is utilized for delivering power to the transmitter. When a particular location required sanitization, we dispatched our robot there. Then after choosing the appropriate spot, we hit the button for the UVC light. Thus, UVC light becomes active, and the sanitization process will run. Here we used UVC light and liquid sanitizer to eradicate the coronavirus. Recent studies show that Ultra-violet radiation (UVC) efficiently exhibits antiviral action against pathogens. Moreover, UVC irradiation with high energy and short wavelengths, notably in the 200–290nm region, holds enormous potential for germicidal eradication. These features of UVC enable damage or destroy the nucleic acids (DNA/RNA) in varied germs (e.g., bacteria, fungus, and viruses). UVC light can consequently be employed



(a)



(b)

Fig. 8: Complete Overview of the Receiver section.

as a promising method for preventing and controlling the infestation or spread of novel coronavirus (2019-nCov). [19]–[21]. However, UVC lamps that emit approximately more than 240 nm can be a health hazard for both skin and eyes [22], [23]. But, UVC light (207 to 222 nm) has been demonstrated to be equally effective as usual germicidal UV light in killing microorganisms. Furthermore, studies indicate that these wavelengths do not create human health risks associated with direct exposure to regular disinfectant UV light [24]–[26].

V. Cost Analysis

In this section, we described the cost analysis of this research. Our prototype cost is approximately Tk.4075. If we wish to create for commercial reasons, the cost will be decreased considerably. The components can be designed on a PCB board. So, in this situation, the cost would reach about Tk.4075, which will be effective as it has a minimal cost. However, a complete feasibility assessment is necessary for the analysis. Table.1 displays the entire cost of the hardware of this prototype.

TABLE I: PRICE ESTIMATION OF THE SUGGESTED SYSTEM

SL	Component Name	Quantity	Price (BDT)
Item 1	ATmega328P	2	880tk
Item 2	nRF24L01	2	400tk
Item 3	Ultraviolet C (UVC) light	1	600tk
Item 4	DC Pump	1	160tk
Item 5	Gear Motor	2	160tk
Item 6	Motor Driver (L298)	2	300tk
Item 7	Wheel	2	120tk
Item 8	Relay Module	1	55tk
Item 9	Lithium ion battery (3.7*3)V	3	300tk
Item 10	IP camera	1	700tk
Total Installation Cost			3675tk
Miscellaneous Cost			400TK

Total cost= Total Installation Cost + Additional Cost= (3675+400) =4075Tk.
Which is approximately 48$ dollar.

Conclusion

The sanitization and disinfection process is too essential in this covid pandemic circumstance. The virus that causes COVID-19 can quickly spread on land and surfaces. People can become infected if they touch certain surfaces and then touch their nose, mouth, or eyes. When people are directly engaged in the sanitization process, there is a significant probability of being impacted by the virus. In this circumstance surface disinfection robot is the best solution. This research was meant to make the sanitization procedure risk-free and protect humans from the Coronavirus. It will be implemented with the current disinfection procedure to minimize dependence on human employees and enhance throughput. This research can be further enhanced in the future. The obstacle detecting system may be incorporated to move the robot autonomously. This robot is only useful on smooth surfaces presently. However, when a belt system is employed for controlling robot chassis, it can be applied to any surface. We may also utilize internet of things (IoT) based networking technology to operate the robot from any location. Thus, many more features may be included in the future in this system.

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