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Internet of things-based robot to take care of the Coronavirus patients and sterilize quarantine rooms

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ABSTRACT

The medical staff is the first part which is affected in the COVID-19 pandemic, then the workers, whether in the hospital or quarantine hotels who are responsible for cleanliness and sterilization. The goal is to reduce the number of injured and preserve human safety. This led us to think deeply to solve this problem and make the life healthier and to reduce the spread of the virus by using internet of things (IoT). The goal of the research is to develop a special robot to sterilize quarantine rooms and hospitals, measure the patient's temperature and heart rate, in addition to transporting medicines to patients in order to preserve the safety of the medical staff. So, in order to accomplish this purpose, we will create a proof of concept for the robot. Our robot will have a system capable of performing pre-programmed acts, either under direct human control or under the control of computer programs. This paper can be the basic for future research in the same field.

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1. INTRODUCTION

There are many reasons that make COVID-19 become one of the hot topics over the world. The rapid spread of it and its serious symptoms are the main reasons. Before the outbreak in the Chinese city of Wuhan in December 2019, there was no evidence of the nature of this new virus or its disease. COVID-19 has now spread around the globe, impacting many nations. Some of the side effects of COVID-19 that differ from one person to another are pain, nasal inflammation, fever, and dry cough. Sometimes, these signs and symptoms are typically mild and they appear slowly over a period of time. The elderly and people with other health issues, such as high blood pressure, are also at a higher risk of experiencing serious complications.

According to recent studies, over 3 million people worldwide have been infected by the coronavirus disease in 2019 during COVID-19 pandemic, with a 6.9% risk of death as of April 27, 2020 [1], [2]. The medical staff is the first part which is affected in this pandemic, then the workers, whether in the hospital or quarantine hotels who are responsible for cleanliness and sterilization, and nowadays the number is increasing greatly. The main goal is to develop a special robot to sterilize quarantine rooms and hospitals, measure the patient's temperature and heart rate, in addition to transporting medicines to the patient in order to preserve the safety of the medical staff [2]. So, in order to accomplish this purpose, we will create a proof of concept for the robot. Our robot will have a system capable of performing pre-programmed acts, either under direct human control or under the control of computer programs [1]. The internet of things (IoT), also known as the, refers to all the devices that can connect to the Internet and capture, transmit, and process data from their environments using built-in sensors and processors as well as communication media. Since they

can communicate with other connected devices through a mechanism known as machine-to-machine (M2M) communication and interact with information provided by the other devices, connected or smart devices are more useful. Humans can communicate with them to customize and give orders, as well as access data, but they do most of the work themselves. Knowing it without the aid of humans, the presence of such devices is made possible by all of the small components of the smartphone that are plentiful these days, as well as the fact that our home or work networks are set to always be connected to the internet [3].

In our research, we employed the robot to take an advantage from the IoT to show solidarity with the world in the spreading pandemic by searching for a technology that contributes to limiting the widespread spread of the virus. Because it is possible that E-doctors and workers responsible for sterilizing the rooms of patients and quarantined people may be exposed to touching one of the surfaces on which the virus is based, this leads to the transmission of infection from the patient or the quarantined to the worker or doctor, and then to other doctors or other workers, and then to the family, and so we enter into the disease cycle to move to the stage of inability to control the number of infected people [4].

The robot is controlled by a mobile phone moving between rooms to carry out the sterilization process by pumping water and the sterilizer inside the container in quantities that are controlled through the pump, and the fan is controlled to carry out the drying process [5] a robot works as a nurse that measures the patient's heart rate and temperature and transports medicines into the patient's room to reduce the spread of Corona virus among the medical staff.

2. THEORTICAL WORKFLOW

This section provides the basic knowledge that plays an important role in understanding the need of our robot in hospitals and the need of IoT. First, we will take a quick look at the virus, its history, symptoms, how to prevent it, and then we will talk about IoT. After that, we will take a look at the definition of a robot.

2.1. COVID-19

In 2019, coronavirus was the main source behind a disease outbreak in China. It is like middle east respiratory syndrome (MERS), and it can cause a lot of symptoms exactly like any common cold. The virus has been identified as COVID-19. The world health organization (WHO) proclaimed the COVID-19 outbreak a pandemic in March 2020. A lot of centers and organization in the United States and also worldwide are keeping tabs on the pandemic and providing information on their websites. These agencies have also provided preventive and recovery guidelines [2].

In 2019, the first appearances of COVID-19 were in China, exactly in Wuhan City. Fingers pointed at a store specialized in selling seafood. Several people who visited the store recently were exposed to the virus. However, scientists and health professionals aspire to discover the main cause behind the virus [6]. The droplets of an infected person can transmit the coronavirus into the air when this person coughs or sneezes, according to researchers. Physical distancing is successful in avoiding the spread.

2.1.1. Symptoms

Symptoms and signs of coronavirus infection COVID-19 will appear anytime from the first day in first week to the second week after exposure. The interval between exposure and onset of symptoms is known as the incubation period. Pyrexia, cough, and tiredness are some of the familiar signs and symptoms. A loss of taste or scent can be one of the first signs of COVID-19.

2.1.2. Prevention

The general safety measures for virus prevention are a few easy steps that will significantly reduce your risk of being exposed to COVID-19, the illness caused by SARS-CoV-2. All can do the following: Cover your coughs and sneezes, don't touch your face, and hand hygiene must be maintained.and if you are at home, avoid direct contact with sick people. Keep a distance of at least 6 feet between you and someone who is not a member of your family. In addition, when in public, cover your face with a cloth. Clean and disinfect regularly handled objects and surfaces on a regular basis [7].

2.2. Internet of things

IoT is a network of connected computers, hardware and digital devices, automotive, home appliances, and other sensors, software, switches, and network connectivity and data collection and sharing. The technology opens the way for electronic devices and offline computers to be connected to the internet and controlled and used remotely. An individual with a heart monitoring implant, a car with a barrier sensor, or mobile equipment linked to an application network are all referred to as objects in the IoT. This is valid for industrial machinery like an oil well drill or a jet engine on an aircraft [8].

All devices are allowed to be operated remotely over the internet by IoT; it has opened up possibilities for connecting and integrating the world with computer-based systems through sensors and the internet. The interconnection of these numerous embedded devices is the main reason that will result in automation in nearly every area, as well as the development of advanced applications. As a result, with less human interference, precision, productivity, and economic gain have increased. Smart houses, smart transportation, and smart buildings are among the innovations covered [9].

2.3. Robot

The name "robot" first appeared in Czech playwright Karl Chabek's (in Czech: Rossumoviuniverzálnroboti) in 1920 [10]. In Czech, the term "robot" means "hard work," as it is born from the phrase "robot," which means "forced labor". ‘’This’’ was created by Joseph Chabek, the brother of the aforementioned playwright, in order to assist his brother in naming what live machines in the theater do. Starting on that date, the word started to spread in science fiction books and films, which have offered a variety of ideas and views of these devices and their connection to man over the years, opening up great opportunities for inventors to evolve and improve as much as possible [11].

There are many different types and shapes of robots found in everything in automatic washing machines and automatic cash machines, until we reach factories, airplanes, spacecraft, robots that are used for cleaning, etc. In fact, there are many different forms and uses of robotics in industry, education, exploration, and military applications where human beings enter all aspects of human life.

3. POROBLEM STATEMENT

Technology grows rapidly, so it becomes necessary to employ technology as a substitute for workersin easier, less expensive, and more efficient ways. With the emergence of COVID-19 disease, the role of doctors in treating the disease and the role of workers in room sterilization became more dangerous. We have employed our roles in protecting their health through utilizing a robot that sterilizes quarantine rooms and hospitals, measures the patient’s temperature and heart rate, in addition to transporting medicines to the patinent’s room n order to preserve the safety of the medical staff through the remote control.

4. PROPOSED DESIGN

In this section, we will talk about the design of the robot and its main functions. As technology advances, robots are gaining the attention of researchers to make human lives comfortable. This research is designed and developed to limit the spread of Coronavirus. This robot limits the spread of Corona disease by entering the rooms of Corona patients instead of the medical staff as shown in Figure 1. This robot contains a number of applications: The first application is to disinfect and clean surfaces. The second application is to deliver medicines to a Corona patient. The third application is to measure the patient's temperature, and the fourth application is to measure the patient's heartbeat.

To perform these tasks, we connected the system to the Blynk app through the IoT and controled this command from outside the patient’s room through the Blynk screen. There are buttons for each application, for example, when you press the button called “up”, the robot will move forward. When the patient touches the heart rate sensor, the values of this sensor appear on the application screen, and so for all applications. The main function of our research is to limit the spread of the Corona virus among the ranks of the medical staff, as it enters the room of a Corona patient and measures the patient's heart rate and temperature, sterilizes, and cleans the surface floors and delivers medicines to the patient. The system will be connected to the internet so that these patient-specific values appear on Blynk app screen by IoT technology. In addition to controlling robot moving of (up, down, left, right) also we will turn the pump and direct current (DC) motor for cleaning movement via the IoT.

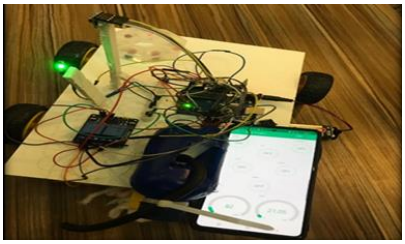

Figure 1. Smart medical robot

5. HISTORY AND RELATED WORK

Due to the fact that COVID-19 is a new virus, this is the first work to our knowledge that tries to design a robot that incorporates sterilization of the environment and patient care at the same time. This fact alone brings with it a slew of new problems. To begin with, it is unclear how to design and execute a robot that can perform all of these tasks in one device.

Students from Turkey created a robot in October 2020 whose primary task is to walk along the lines placed on the hospital floor and transfer the patient from the ambulance to the stone room using an Arduino program. Their project was wonderful and their idea could be implemented, but they did not consider sterilization and concern for the health of patients [12]. Although in 2019, researchers built a robot to take examination samples from the patient's nose, the importance of robots in facilitating the lives of Corona patients has been emphasized in many cases. Designing such a robot to assist nurses in their jobs decreases the rate of injury and alleviates pain during examinations, which is a good idea. However, in my opinion, they did notdesign a multifunctional integrated robot [13].

In July 2020, researchers from London have created a robot that can be controlled with facial gestures to assist and transport people with disabilities. It is a new concept, but it has not been well received by Corona patients [14]. This concept may be utilized to help Corona patients. We should note that robots have been used to serve and assist people since ancient times, especially patients in hospitals, and that with the emergence of the Corona virus, the demand for sterilization robots has increased in order to avoid the spread of infection and reduce the number of deaths. Our robot was the most effective way to combat the Corona virus in hospitals by taking care of patients' health and sterilizing at the same time [14], [15].

6. OPERATION OF HARDWARES

In this section, we will show the hardware diagram of our medical robot based on IoT. There is a collection of different hardware and sensors that were used to build our medical robot. This collection is shown in the Figure 2. In our research, Arduino plays an important role which is the brain of the system. In the next subsection, we will show the different hardware used to make the different important functions.

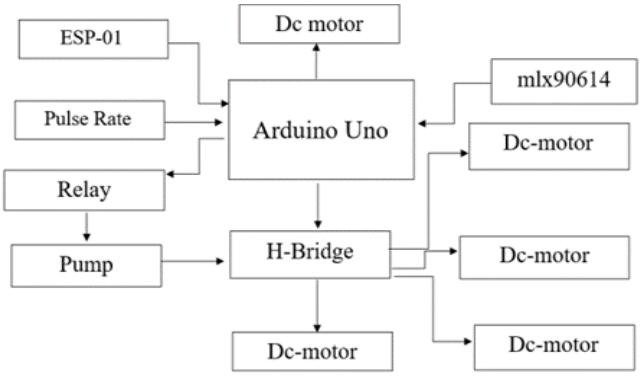

Figure 2. Block diagram for the research

6.1. ESP-01 shield

The ESP-01 is shown in Figure 3. It represents shield modules used in this research to connect access points (Wi-Fi network). They are used to order the application of IoT.

6.2. Relay

A relay, as shown in Figure 4, is a switch that is operated electrically which can be switched on or off, allowing or disallowing current flow, and the voltage that Arduino pins which is 5 V will be enough to turn on the relay switch, so we can say it is controlled with low voltages. An electromagnet operates a relay, which is actually a switch. The electromagnet needs a small voltage to activate, which will be generated by the Arduino, and once activated, the contact will be pulled in order to complete the high voltage circuit. The relay module SRD-05VDC-SL-C will be used. It runs on 5 volts and can be powered by any microcontroller, but we will use Arduino. As we will see later, controlling a relay module with the Arduino is as easy as controlling any other output [15], [16].

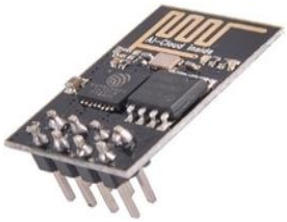

Figure 3. ESP-01

Figure 4. Relay

6.3. DC-motor

Any rotary electrical motor that converts direct current electrical energy into mechanical energy is known as a DC motor, as shown in Figure 5. Magnetic fields are being used in the mostly common ways to generate forces. Forces are produced in a variety of methods. Nearly each DC motor has an internal mechanism, either electronic or electromechanical, that occasionally alters the current direction in a motor component. DC motors were the first kind of motors to become widely used and they may be powered by existing direct-current lighting power distribution systems. Through varying the supply voltage or adjusting the current intensity in the windings of the field. The speed of a DC motor may be adjusted over a wide range. Tools, toys, and appliances all use small DC motors [17].

The most common type of motor is the DC motor, or direct current motor. There are only two possible corps in the majority of DC motors: one negative and one positive. The motor will spin if these two corps are wired directly to a charger. The engine would spin in the opposite direction if the corps are reversed. Without making any changes to the leads or corps, an H-Bridge circuit may be utilized to regulate the direction of a spin of a DC motor.

6.4. H-bridge

The H-bridge represents a kind of electronic circuit of bidirectional operation. H-bridges have a wide range of uses. Controlling motors in robotics is one of the most popular applications. It is called an H-bridge because it is made up of four transistors joined in an H shape. The H-bridge is called after the fact that it employs four transistors that are linked in such a manner that the schematic diagram looks like an "H".

The H-Bridge IC L298 will be included in this application. The speed and direction can be controlled by L298 for stepper and DC motors, as well as two of them simultaneously. Every motor has a current rating of 2 A [18]. Every motor has a current rating of 2 A [18]. An H-bridge is shown in Figure 6. It represents a basic circuit that enables you to control a DC motor to go up or down. It is usually used in conjunction with a microcontroller, such as an Arduino, to control motors. You may build a robot if you can handle two motors to go up or down.

Depending on how you link the plus and minus, a DC motor can turn up or down. An H-bridge is made up of four switches that regulate current flow to a load. The load in the picture above is the M that connects the two sets of switches. By closing two switches, you can push the current in two directions using a single current source. You will quickly flame out the H-bridge if you make a short circuit. At digit lent, I might have burnt out my first H-bridge. The most common use of an H-bridge circuit is for motor control. If you drive the motor and change directions at the same time, the H-bridge circuit will flame out. Just keep in mind that where there is current and course, there is a risk of H-bridges being burned. For motor control, digit lent provides three peripheral modules (Pmods) with H-bridge circuits. The Pmod HB5 controls a single DC motor using a 6 Pin connector, the Pmod HB3 controls a single DC motor via screw terminals, and the Pmod DHB1 controls two DC motors or a single stepper motor [19].

Figure 5. DC-motor

Figure 6. H-bridge

6.5. MLX90614

MLX90614 is shown in Figure 7. The MLX90614ESF-BAA infrared thermometer from Melexis is a sensor that is equipped for non-contact temperature sensing. An internal 17-bit ADC and an efficient DSP help the MLX90614 achieve high precision and resolution. It can be used for multiple uses, like measuring body temperature and detecting activity.

There are two output performance options for The MLX90614: pulse width modulation (PWM) and SMBus (i.e., TWI, I2C). The TWI GUI has a 0.02 ℃ resolution, while the 10-bit PWM has a resolution of 0.02 °C; the display has a resolution of 0.14 °C. The MLX90614 is factory optimized for a wide range of temperatures: -40 to 85 °C for ambient temperature and -70 to 382.2 °C for object temperature. The average temperature of all points in the sensor's field of view is the calculated value. Around room temperatures, the MLX90614 has a typical accuracy of 0.5 ℃ [20].

6.6. Pulse rate

Pulse sensor for Arduino is a well-designed plug-and-play heart rate sensor. Students, musicians, performers, makers, game and mobile creators, and those who choose to integrate live heart rate data into their projects will do it. The sensor is attached to a fingertip or earlobe and uses extension cords to bind to Arduino. It also comes with a free tracking tool that graphs your heartbeat [21]. As shown in Figure 8, the pulse sensor kit includes:

- Color-coded 24-inch cable with (male) header connectors. This makes it simple to integrate the sensor into your project and attach it to an Arduino. There is no need for soldering.
- An ear clip that is the very same size as the sensor is used. We aimed for the right picture in a number of locations. It is quickly worn on the earlobe after becoming hot pressed to the bottom of the sensor.
- Velcro splotches are on the 'hook' end of the continuum and are a decent match for the sensor. If you want to make a Velcro (or fabric) strap to tie around a fingertip, these Velcro dots can come in handy. Velcro strap to wrap the Pulse sensor around your finger.
- Stickers that are translucent. To shield the pulse sensor from sticky fingertips and moist earlobes. These are placed on the front.

The pulse sensor has three holes along the outer lip, making it simple to stitch into almost any fabric. The sensor's good side has a heart mark on it. This is the hand that comes into close contact with the blood. On the front, there is a small circular hole in which the light-emitting diode (LED) shines from the back, as well as a small square just under the LED. The square is an ambient light sensor, like those used in phones, tablets, and laptops, that allows the screen brightness to be adjusted in various conditions. The LED beams light through the fingertip, earlobe, or other capillary tissue, and the light bounces out, which is detected by the sensor. The remainder of the components are mounted on the back of the sensor. We positioned them there to get them out of the way of the front-facing sensor. It is also a reverse mount LED that we are using. More details on the circuit's operation can be found here. The cable is a 24” flat color-coded ribbon cable with 3 male header connectors.

Figure 7. MLX90614 sensor shape

Figure 8. Pulse rate

7. SOFTWARE REQUIREMENT

7.1. The open-source arduino software IDE

As seen in Figure 9, the open-source arduino software (IDE) makes writing code and uploading it to the board a breeze. It works for Windows, Mac OS X, and Linux. The world is written in Java and uses open-source software including processing. This software can be used for any Arduino surface [22].

7.2. Blynk

As seen in Figure 10, Blynk is a network for IOS and Android applications for controlling Arduino, Raspberry Pi, and other related devices over the internet. Blynk was built with the IoT in mind. It can monitor hardware remotely, view sensor data, store data, simulate it, and perform a number of other tasks

[23], [24]. The platform is made up of three main components: Blynk App enables you to build complete spectacular interfaces for all your different projects by combining different widgets. Blynk Server - The Blynk Server is in charge of all smartphone-to-hardware communications. You can use our Blynk Cloud or set up your own Blynk server on your own computer. Since it is open source, it can quickly accommodate tens of thousands of computers. For all popular hardware platforms, via Blynk Libraries, you can communicate with the server and process both send and receive commands.

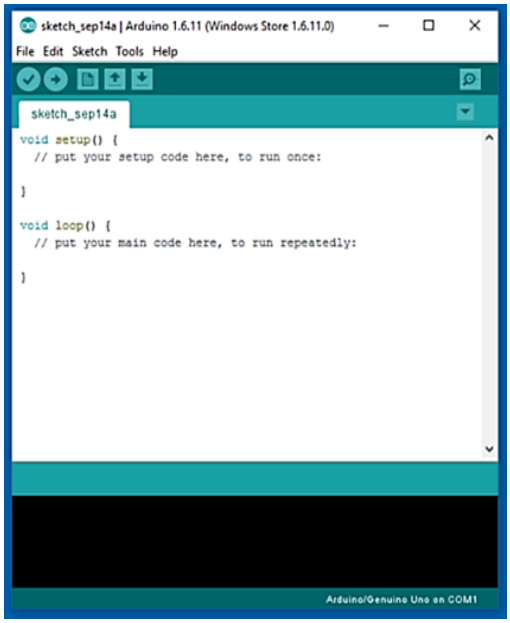

Figure 9. Arduino software (IDE)

Figure 10. Blynk

8. RESULTS

So far, there has been no prototype done to assess the impact of this system that will be automatic, so that it can be controlled remotely, and determine the direction of movement to perform the sterilization process. We developed the system to make it suitable to be used in hospitals and quarantine places in order to increase the protection of people who work in areas with a high number of affected patients, such as doctors, nurses and security personnel.

As a result of this autonomous IoT-based floor cleaning robot, each portion performs correctly, and the whole device is a completed success. This works well in terms of movement in a room-wide direction and room washing. We tested the functionality of our research by connecting it to batteries and testing its cleaning and moving mechanism, which is operated by a DC gear motor and a pump. This approach is environmentally sustainable, and the machine cleans properly using a DC motor cleaner and a pump, which is operated by IoT. Furthermore, the device can be controlled through the Blynk app. As we said, the medical robot has several applications and its main goal is to reduce the spread of COVID-19 disease. This robot can be used in hospitals and quarantine rooms where it sterilizes surfaces and floors, enabling the robot to check the patient's heartbeat and the patient's body temperature. This robot can help transport medicines and medical equipment between patient rooms. The results are divided into four parts, and they will be discussed briefly in the following subsections:

8.1. Delivers medicines

The first application of the robot is that it delivers medicines. Figure 11 shows the process of delivering medicines. The robot moves through four DC-motors connected to the h-bridge and the movement is controlled by Blynk application [25].

8.2. Sterilizes surfaces

The second application of robots as shown in Figure 12 is to sterilize surfaces and floors. As displayed in Figure 12, when the robot enters the room of a Corona patient, it performs a complete scan to

evaluate the surfaces by pumping the sterile material from the pump in addition to the rotating movement through the DC-motor for the sterilization process that we have connected individually on the arduino.

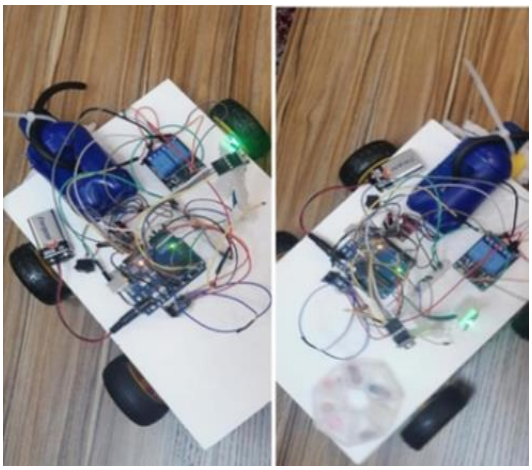

Figure 11. Delivers medicines

Figure 12. Sterilizes surfaces and floors

8.3. Measuring the patient's temperature

The third application for the robot is measuring a patient's temperature. As shown in Figure 13, when the robot reaches a Coronavirus patient, it measures the temperature through the MlX90614 sensor. It is designed to sense the non-contact temperature by an infrared thermometer.

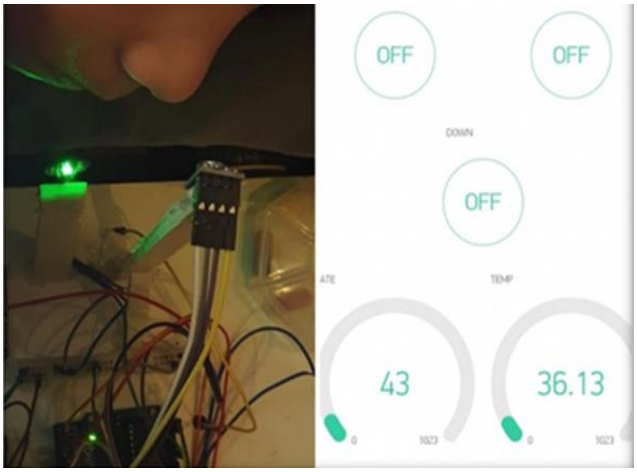

Figure 13. Measuring a patient's temperature

8.4. Measuring the patient's heart rate

The fourth application of the robot is to measure the patient's heart rate. In this research, the design and development of a heart rate meter that efficiently measures the heart rate in a short time and with less system is presented. The heart rhythm could be detected by changes in blood flow through the index finger, according to the simulations. Since this instrument can track, filter, digitize, and monitor the pulse, the experimental findings revealed that the heart rate can be 60-90 in the normal place. We have now put the index finger inside the pulse sensor to test the heart, as seen in Figure 14.

After measuring the temperature and heart rate and delivering the medication to a Corona patient, the values will appear on the Blynk application screen. The robot leaves the patient's room and completes the process repeatedly in all Corona patients' rooms. By that, data regarding all Corona patinets is found on the Blynk application screen.

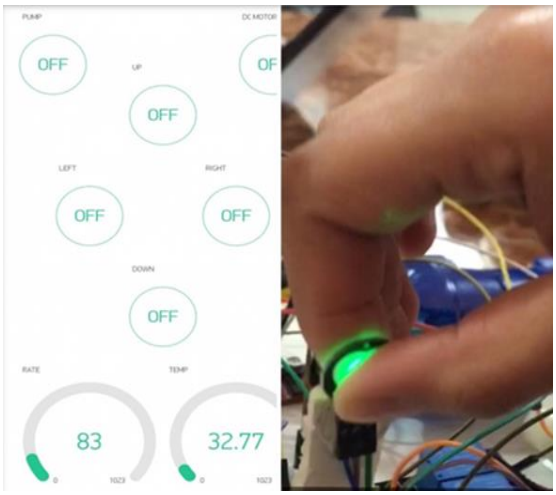

Figure 14. Measuring the patient's heart rate

9. CONCLUSION AND FUTURE WORK

The research goal is to develop a special robot to sterilize quarantine rooms and hospitals, measure the patient's temperature and heart rate, in addition to transporting medicines to the patient in order to preserve the safety of the medical staff. The research is definitely a very important system in robotics, disinfect surfaces and floor cleaning area. The robots were developed to use a pump and DC motor which clean and sterilize surfaces of floor. The system is more secure for people who work at hospitals. It will be great research and can decrease the spread of the COVID-19. The internet of robotic things is being created by bringing together the IoT and robotics cultures (IORT). The IORT is a philosophy in which autonomous devices can track activities in their environment, fuse sensor data, use local and distributed information to make decisions, and then function to influence or manage objects in the physical world.

This robot can be modified in the future to perform more efficiently and serve many purposes. Cleaning performance can be increased. We can make a system that works wonderfully for cleaning by using an IR sensor and adding other features. It may be used as a pathogen in the future to avoid illness from occurring in various areas. For remote control, more sophisticated medical devices may be installed.

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