Medical Robot Based on Wireless Communication and Remote Control

Sondos Mohammed, Aya Mohammedy, Aya Gamal, Alaa salah, Reham Shehata
Mohammed Ashraf, Ahmad Ragab, Mohammed Abd Elhady, Mohammed Mostafa, Mohammed Elgbawy

Menoufia University, Egypt, sundus.mohamed14156@hsc.menofia.edu.eg, mohamed.ashraf14186@hsc.menofia.edu.eg, mohamed.abdalhady14192@hsc.menofia.edu.eg.

Supervisor: Dr.Essam Abdelalim Gomaa, Department of Industrial Electronics and Control Engineering, Faculty of Electronic Engineering, Menoufia University, 32952 Menouf, Egypt.
Faculty of Applied Medical Science, Egypt, essam.elarabi@el-eng.menofia.edu.eg.

Abstract

Medical robotics is an interdisciplinary field that focuses on developing electromechanical devices for clinical applications. The goal of this field is to enable new medical techniques by providing new capabilities to the physician or by assisting with surgical procedures. Medical robots can play an important role in decreasing the spread of infectious diseases and delivering quality care to patients during the COVID-19 pandemic. COVID-19 is a respiratory viral disease with transmission via respiratory aerosols and microdroplets. This places clinicians and healthcare professionals at risk of contracting the virus when caring for patients infected with COVID-19. So, medical robots have the unique capability to bridge the gap between remote healthcare providers and patients by interacting with imaging and therapeutic equipment and with patients, ushering in the next generation of telecare. Methods and procedures involving medical robots in the continuum of care, ranging from disease prevention, screening, diagnosis, treatment, and home care, have been extensively deployed and also present incredible opportunities for future development. Our graduation project has produced a medical mobile robot. Such a robot has been controlled wireless to record and send the vital measurements remotely to the clinical staff. This paper presents the construction, operation, and control techniques in detail.

INTRODUCTION

Disinfection is one of the key measures against infectious diseases. So, robotics can play a key role in combating infectious diseases in four areas, including clinical care, logistics, reconnaissance, and continuity of work and maintenance of socioeconomic functions [1]. Here, we focus on the first area. Physicians and nurses who have not been trained or practiced emergency medicine and intensive care in years are now being deployed to COVID-19 units. This can bring up issues regarding malpractice and scope of practice concerns combined with personal protection equipment shortages, adding to the risk these physicians and nurses have to take care of COVID-19 patients. The first reports of a novel coronavirus in December 2019, more than 44.7 million patients have been infected worldwide, and more than 1.17 million patients worldwide have died from COVID-19, the disease caused by this virus (numbers as of 29 October 2020) [2]. Among them, 19% of infected persons were hospitalized, while 6% were admitted to intensive care units (ICUs) [3]. Health-care professionals acted as the front line against the virus, resulting in a large exposure risk to infection. The robotic community also took charge of an important role in providing aid to manage the pandemic and great efforts were made to adapt pre-existing devices to the new challenges, which translated into many helpful solutions [3]. Health robotics enable a high level of patient care, efficient processes in clinical settings, and a safe environment for both patients

and health workers. Robots are now used not only in the operating room but also in clinical settings to support health workers and enhance patient care. During the COVID-19 pandemic, hospitals and clinics began deploying robots for a much wider range of tasks to help reduce exposure to pathogens. It's become clear that the operational efficiencies and risk reduction provided by health robotics offer value in many areas.

A) *Benefits of Robotics in Healthcare*

a. High-Quality Patient Care

b. Operational Efficiencies

1-How does it work?

We are now about to present our prototype of a medical mobile robot in detail. Our robot structure is built on:

a. Control (HC-05 Bluetooth module)

b. Brain (Arduino Mega)

c. DC motors with Driver

d. Display (LCD with IIC)

e. Heart Rate Sensor and SPO2

f. Temperature Sensor

A robot is a mechanical or virtual artificial agent, usually an electro-mechanical machine that is guided by a computer program or electronic circuitry. There are several ways for wireless communication such as NRF, ZigBee, Wi-Fi, and Bluetooth.

A. *Control*

Bluetooth is a wireless technology standard for exchanging data over short distances from fixed and mobile devices, and building personal area networks. Bluetooth technology was created by Ericsson in 1994 and is used to replace the cables in the office, in laboratories, or at home. Bluetooth device operated in the range of 10 meters. The IEEE standardized Bluetooth as IEEE802.15.1. HC-05 module is a Bluetooth module using serial communication, mostly used in electronics projects.

a. HC05 Bluetooth module important specifications:

- Working voltage: 3.6V – 5VInternal antenna: Yes
- Automatic connection to the last device: Yes

HC05 module has an internal 3.3v regulator and that is why you can connect it to 5v voltage. But we strongly recommend 3.3V voltage, since the logic of HC05 serial communication pins is 3.3V. Supplying 5V to the module can cause damage to the module. To prevent the module from damages and make it work properly, you should use a resistance division circuit (5v to 3.3v) between the Arduino TX pin and module RX pin[4].

b. App for Bluetooth Communication

I am using a simple Android App called "Bluetooth Controller" for pairing HC-05 with my Android Phone and transmitting data. Once the Bluetooth Module is paired with your phone, you can start using the Application.

B. Brain of Robot

The brain of the robot is connected with different sensors and actuators of the robot. The sensors are the input to the brain and the output of the robot is executed using actuators. The brain of the robot is responsible for reading the data from sensors, perform different computations on the sensor data, and make a decision based on the data. The decisions made by the robot brain can be executed using different actuators. There is a different type of microcontroller used in robotics such as Arduino. Arduino is an open-source microcontroller which can be easily programmed, erased, and reprogrammed at any instant of time. Introduced in 2005 the Arduino platform was designed to. It is also capable of receiving and sending information over the internet with the help of various Arduino shields, which are discussed in this paper. Arduino uses hardware known as the Arduino development board and software for developing the code known as the Arduino IDE (Integrated Development Environment). Built up with the 8-bit Atmel AVR microcontrollers that are manufactured by Atmel or a 32-bit Atmel ARM, these microcontrollers can be

programmed easily using the C or C++ language in the Arduino IDE[6]. There are several types of Arduino boards such as Mega. Arduino Mega is based on ATmega2560 Microcontroller, an 8-bit AVR Architecture-based MCU from ATMEL. It is available in a 100-pin Quad Flat Package. It is designed and developed to provide a greater number of IO lines (both Digital and Analog), more flash memory, and more RAM when compared to UNO.

Table 1 specification of Arduino [7]

Microcontroller	ATmega 2560
Operating Voltage	5v
Output voltage	7-12v
Input voltage	6-20v
Flash memory	256KB (8 used by bootloader)
SRAM	8KB
EEPROM	4KB
Clock speed	16MHZ

C. Mechanical part

Mechanical parts are components that are used as the main structure of a robotics system. Robots all consist of some sort of mechanical construction. The mechanical aspect of a robot helps it complete tasks in the environment for which it's designed. These include motors, wheels, etc.

a. DC motor

The DC motor is another main type of electrical motor that only runs on DC or Direct Current. There are no phases in direct current that is why DC electric motors only use 2 wires to run. It is easier to control its speed by only varying the supply voltage.

Advantages of DC Machines:

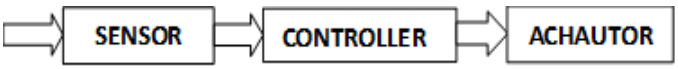
A. High starting torque
B. Rapid acceleration and deceleration
C. Speed can be easily controlled over the wide speed range
D. Speed can be easily controlled over the wide speed range
E. Built-in a wide range of sizes[5]

Disadvantages of DC Machines:

A. Needs regular maintenance
B. High cost

b. Motor Driver

We use a motor driver to control the speed and directions of motors. It is a low voltage operating device like other ICs. The other ICs could have the same functions as L293N but they cannot provide the high voltage to the motor. L293N provides the continuous bidirectional Direct Current to the Motor. The Polarity of current can change at any time without affecting the whole IC or any other device in the circuit.



D. Display device

A display device is an output device for the presentation of information in visuals. When the input information that is supplied has an electrical signal the display is called an electronic display.

These are the technologies used to create the various displays in use today[8].

A. Electroluminescent (ELD) display
B. Liquid crystal display (LCD)
C. Light-emitting diode (LED) display
D. Plasma (PDP) display
E. Quantum dot (QLED) display

a. Liquid crystal display (LCD)

We are using a Liquid crystal display in our project. A liquid-crystal display (LCD) is a flat-panel display or another electronically modulated optical device that uses the light-modulating properties of liquid crystals combined with

polarizers. Liquid crystals do not emit light directly[9], instead of using a backlight or reflector to produce images in color or monochrome. LCDs can either be normally on (positive) or off (negative), depending on the polarizer arrangement. For example, a character positive LCD with a backlight will have black lettering on a background that is the color of the backlight, and a character negative LCD will have a black background with the letters being of the same color as the backlight. Optical filters are added to white on blue LCDs to give them their characteristic appearance.

b. LCD serial interface board

I2C Module (I2C, IIC) is a serial 2-wire bus for communicating with various devices, which will reduce wire connections between Arduino and LCD to just 2 wires, also saving tons of GPIO pins for other sensors/drives, etc. The major advantage of the I2C protocol is that we can wire the supported sensors/input / output devices in just two lines and it is helpful with Arduino as it has limited GPIO pins. The module has 16 output pins and 4 input pins.

2- Roles of Robot in hospital

The heart is an important organ that helps to supply blood and oxygen to all parts of the body. Therefore, we are interested in measuring the heart rate and the percentage of oxygen saturation in the blood (SPO2), and Temperature.

A. Heart Rate

According to researchers of the same study app, COVID-19 can cause an irregular or high heart rate - over 100 beats per minute. Because of its sensitivity, heart rate variability can be a very useful index to tell us how our bodies are doing, especially during the COVID-19 pandemic. Fever and infection cause the heart rate to speed up, increasing the work of the heart in COVID-19 patients who develop pneumonia.

b. Blood Oxygen Saturation (SPO2)

Pulse oximetry's ability to provide an early warning for many lung-related issues is why some clinicians are recommending their COVID-19 patients periodically monitor their SpO2. More generally, clinicians frequently measure patients' SpO2 during simple checkups because it is a fast, easy way to flag potential health concerns or rule out others. The normal values of SpO2 range from 92 to 100 percent. For a healthy person, SpO2 values usually fall between 94-96 percent. However, a value below 90 percent during a COVID-19 outbreak could indicate a low oxygen level, a condition known as hypoxemia. it's important to know when a change in your **SpO2** reading becomes significant.

c. Temperature of Body

The infectivity of viruses is affected by changes in temperature, and the human coronavirus SARS-CoV-2, which causes coronavirus disease 2019 (COVID-19), is no exception. The stability of SARS-CoV-2 at temperatures close to normal core body temperature suggests that temperature may play a particularly significant role in the transmission and severity of COVID-19. In vitro data indicate that viral stability may be particularly sensitive to fluctuations around 37°C. Variation of temperatures in the body and between individuals may therefore result in substantially different rates of viral growth. A variety of factors can influence temperatures in the body. Air temperature stands out as particularly relevant because it can directly influence temperatures in the URT, an area that plays a key role in the transmission and pathogenesis of COVID-19. Additionally, core body temperatures vary between individuals and may also influence disease severity. This review examines the roles of air temperature and core body temperature in the transmission and severity of COVID-19[10].

3) Technologies used in Heart Rate

a. ECG (electrocardiography) sensors measure the bio-potential generated by electrical signals that control the expansion and contraction of heart chambers.

b. PPG (photoplethysmography) sensors use light-based technology to sense the rate of blood flow as controlled by the heart's pumping action.

A. Bio-sensor (MAX30102)

The MAX30102 is integrated pulse oximetry and a heart-rate monitor module. It includes internal LEDs, photodetectors, optical elements, and low-noise electronics with ambient light rejection. The MAX30102 provides a complete system solution to ease the design-in process for mobile and wearable devices. The MAX30102 operates on a single 1.8V power supply and a separate 3.3V power supply for the internal LEDs. Communication is through a standard I2C-compatible interface. The module can be shut down through software with zero standby current, allowing the power rails to remain powered at all times[11].

a. *Benefits and Features*

I. Heart-Rate Monitor and Pulse Oximeter Sensor in LED Reflective Solution
II. Tiny 5.6mm x 3.3mm x 1.55mm 14-Pin Optical Module
• Integrated Cover Glass for Optimal
III. Ultra-Low Power Operation for Mobile Devices
•Programmable Sample Rate and LED Current for Power
•Low-Power Heart-Rate Monitor (< 1mW)
• Ultra-Low Shutdown Current (0.7µA)
IV. Fast Data Output Capability
•High Sample Rates
V. Robust Motion Artifact Resilience
•High SNR
VI. -40°C to +85°C Operating Temperature Range

b. Applications

Wearable Devices
Fitness Assistant Devices
Smartphones [11]
Tablets

B. Bio-sensor (NTC Thermistor)

The Thermistor Thermal Temperature sensor module consists mainly of the NTC Thermistor, LM393 Comparators, Variable Resistor (Trimmer), Power LED, output LED. measures temperature changes. This module can provide both digital and analog outputs. Thermistors are temperature-sensing elements made of semiconductor material that has been sintered to display large changes in resistance in proportion to small changes in temperature stands for "Negative Temperature Coefficient. NTC thermistors are resistors with a negative temperature coefficient, which means that the resistance decreases with increasing temperature. They are primarily used as resistive temperature sensors and current-limiting devices. NTC sensors are typically used in a range from −55°C to 200°C. In code, the temperature of the NTC thermistor is calculated by using the Steinhart–Hart equation

Steinhart–Hart β parameter equation :

$$1/T = 1/To + 1/B \ln(R/Ro)$$

T – Temperature

T_o – Nominal Temperature, 25 °C or 298.15 K

B – Beta co-efficient

R – Measured resistance of the thermistor

R_o – Nominal Resistance, resistance at temperature T_0 is 25 °C or 298.15K

The temperature value in kelvin for the respective resistance (R) of NTC thermistor, $T = 1 / (1/To + 1/B \ln(R/Ro)$

ACKNOWLEDGMENT

In the name of Allah, the Most Gracious and the Most Merciful. All praises to Allah and His blessing for the completion of this thesis. Special appreciation goes to my supervisor, Dr.Essam Abdelalim Gomaa for his supervision and constant support. His invaluable help of constructive comments and suggestions have contributed to the success of this paper. I would like to express my appreciation to the Dean of our college, Dr. Hiyam A. Ayyad, for providing us with the necessary facilities during the execution of this

project.

REFERENCES

[1] G.-Z. Yang et al., “Combating COVID-19—The role of robotics in managing public health and infectious diseases,” *Sci. Robot.*, vol. 5, no.
40, p. eabb5589, 2020. doi: 10.1126/scirobotics.abb5589.

[2] “Coronavirus resource center,” Johns Hopkins University & Johns Hopkins Medicine, Baltimore, MD, 2020. [Online]. Available: https://coronavirus.jhu.edu/

[3] G.-Z. Yang et al., “Combating COVID-19—The role of robotics in managing public health and infectious diseases,” Sci. Robot., vol. 5, no.40, p. eabb5589, 2020. DOI: 10.1126/scirobotics.abb5589

[4] electropeak, Getting Started with HC-05 Bluetooth Module & Arduino - Arduino Project Hub, April 12, 2019.

[5] TY - CHAP AU - Al-Naib, Ahmed PY - 2019/05/03 SP - T1 - DC Motors ER - @inbook {inbook, author = {Al-Naib, Ahmed}, year = {2019}, month = {05}, pages = {}, title = {DC Motors}}

[6] @inproceedings{inproceedings,author = {Louis, Leo},year={2018},month = {07},pages = {},title = {Working Principle of Arduino and Using it as a Tool for Study and Research},volume = {1},journal {International Journal of Control,Automation,CommunicationandSystems},doi={10.5121/ijcacs .2016.1203}}

[7] @article{article,author = {Vidal-Pardo, Antonio and Pindado, Santiago},year = {2018},month = {07},pages = {},title = {Design and Development of a 5-Channel Arduino-Based Data Acquisition System (ABDAS) for Experimental Aerodynamics Research},volume = {18},journal = {Sensors},doi = {10.3390/s18072382}}

[8] Lemley, Linda. "Chapter 6: Output". Discovering Computers. University of West Florida. Archived from the original on 14 June 2012. Retrieved 3 June 2012.

[9] Lawrence Ulrich: BOSCHs smart visual visor tracks sun. IEEE Spectrum, 29 January 2020. Retrieved 17 March 2020.

[10] Kang, D.; Ellgen, C. The Role of Temperature in COVID-19 Disease Severity and Transmission Rates. Preprints 2020, 2020050070 (DOI: 10.20944/preprints202005.0070.v1).

[11] Maxim Integrated Products, datasheet of High-Sensitivity Pulse Oximeter and Heart-Rate Sensor for Wearable Health(MAX30102), https://pdf1.alldatasheet.com/datasheetpdf/view/859400/MAXIM/MAX30102.html, 2018.

[12] TE CONNECTIVITY SENSORS, datasheet of NTC THERMISTOR SENSORPERFORMANCE,https://www.bing.com/search?q=NTC+Thermistor++researshGate&go=Search&qs=ds&form=QBRE, 02/2018.