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IoT-based Telepresent Doctor Robot

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ABSTRACT: Person-to-Person contact during the epidemic has been very dangerous for the Doctor, Medical staff, as well as the Patient. Often, doctors are needed to work, and are required keep working extensively at various hospitals, through a very short period. But it is not feasible for every doctor to be available at every place at any given time. Telepresence is one of the latest emerging fields in robotics. The objective of this work is to propose an IoT based Telepresent Doctor Robot, which is a user friendly, Health Robotic Machine with a user interface which is interactive, for patients' medical necessities. In the case of an emergency, a doctor will be available online through video conferencing and based on the seriousness of the patient's medical conditions, a call can be initiated by a doctor to book an ambulance. In non-emergency cases, the system can also generate medicine prescriptions depending on the patient's health parameters, measured by the different sensors integrated to the robot itself. Such robots can be used in the Healthcare domain to ensure assistance and to reduce individual-to-individual interaction.

KEYWORDS: Internet of Things, Telepresence, Healthcare, Doctor, Robot, Medicine, Pre-prescription, Video Conferencing, Health Parameters.

I. INTRODUCTION

The recent (as of August, 2022) Covid-19 pandemic has exposed the existing hospital infrastructure of our country to the lack of beds, resources, and medical experts, that has costed a lot of lives. Although the pandemic is well under control now, the overdependence on a single doctor remains persistent. Overcrowding of patients at hospitals makes it difficult for doctors to tend to all the patients. Doctors are needed to work extensively at various hospitals, through a very short period, simultaneously. But it is not possible for every doctor to be available at every place at any given time. At present, all the means of video consultations in the Healthcare domain are restricted to only verbal communication between the doctor and the patient, and the doctor does not have physical access to the latest/current medical reports of the patient. So, in order to avoid overcrowding of patients at the hospitals and reduce the burden on the doctors, we have created an IoT based Telepresent Doctor Robot. With the help of this robot, doctors can tend to multiple patients at various locations in the hospital, in less time. Using video consultation, the doctor can have an interaction with the patient, using the assistance of this robot. Currently, we have integrated sensors which can measure the Oxygen level and the Heart Rate of the patient, and display them on the LCD screen present. These parameters will be visible to the doctor, and after analysing these parameters, the doctor can recommend the required treatment and medication to the patient, and take a call of examining the patient physically (if needed), based on the patient's current condition. Through this robot, the doctor can inter-act with more patients in lesser time and prioritize their patients accordingly.

II. RELATED WORK

The authors Jitheesh P, Fasal Keeramkot, Mohammed Ameen T, Athira P C, and Madeena S developed a telepresence robot doctor that is likely designed to allow patients to get medical care without the need for a doctor to be physically pre-sent. A doctor can manoeuvre the robot about the patient's room under remote control using a computer or tablet. This makes it possible for the doctor to examine the patient, monitor their vital signs, and communicate with



them in real time [1]. The writers Ayeesha Mahveen and Prof. Chethana Patil have developed an Internet of Things Virtual Doctor Robot to allow patients to receive medical support from the comfort of their homes. The information the robot gathers and transmits about patient's vital signs, such as heart rate and blood pressure, can be used by healthcare professionals to make justifiable decisions about the patient's care [2]. Authors Dr. M. Sudha, M. V. Yuvabharathi, and S. Sushmitha may have developed an Internet of Things virtual doctor robot to provide patients with re-mote medical guidance and support. The robot may collect data from a variety of sources, including wearable technologies and medical sensors, to monitor a patient's health. Additionally, the robot might examine this data and provide the patient with personalised health recommendations, including reminders to take their prescriptions or get some exercise [3]. In order to advance telemedicine and telehealth, authors Divya Ganesh, Gayathri Seshadri, Sumathi Sokkanarayanan, Panjavarnam Bose, Sharanya Rajan, and Mithileysh Sathiyarayanan employed IoT technology to build a smart automated health equipment. The tool is designed to help individuals remotely monitor their health and give real-time information to medical professionals. The machine's various sensors, including blood pressure and temperature sensors, can be used to assess a patient's health. The data is transferred to healthcare professionals via an IoT platform so they can monitor the patient's health and provide the necessary medical direction and support [4]. The writers Sharanya Rajan and Mithileysh Sathiyarayanan may have investigated the possible benefits of this practise in physiotherapy. Using touchless motion sensing technology, the Leap Motion device uses infrared cameras to recognise and track a person's hands and fingers. This system enables real-time monitoring of a patient's progress during physical therapy. It can also provide feedback to the patient and the healthcare professional, allowing them to adjust the therapeutic strategy as needed [5]. In a publication, authors Y. K. Kim, K. H. Lee, and J. H. Choi describe the design and development of an IoT-based virtual doctor robot for remote health monitoring. Several health indicators, such as body temperature, blood pressure, and heart rate can be measured by the robot, who can then transmit the results to a nearby doctor for review [6]. A paper by K. Vijayarani and M. Tamilarasi provides a comprehensive analysis of cutting-edge IoT virtual doctor robots for remote health monitoring. The survey covers the key features and functionalities of these robots, as well as the challenges and bright prospects [7]. The research by authors N. Al-suggested Emran and M. Al-Qutayri assesses the body of knowledge for IoT-based virtual doctor robots for healthcare services. The article discusses potential applications for these robots in the healthcare sector and goes over some of its crucial parts, including as sensors, communication systems, and data analytics [8]. Authors S. Wang, X. Chen, and J. Liu have proposed a paper outlining an Internet of Things (IoT)-enabled virtual doctor robot for remote diagnosis and treatment. The robot may interact with patients utilising a natural language interface and provide real-time diagnostic and therapy recommendations based on the patient's symptoms and medical history [9]. The authors Y. Zhao, L. Li, and Y. Huang have developed and built a virtual doctor robot for home healthcare. The robot can monitor the health of elderly individuals and provide individualised healthcare services in accordance with their needs and preferences [10]. The Cloud-based IoT Virtual Doctor Robot is a piece of technology developed by authors Y. Li, J. Zhang, and X. Li that makes use of cloud computing and IoT to remotely monitor and diagnose patient health. With the aid of this technology, medical professionals could remotely advise and assist patients, enhancing the efficacy and efficiency of healthcare services [11]. The IoT Virtual Doctor Robot developed by authors S. Venkatesan and S. K. Garg for the early detection and prevention of cardiovascular ailments is a practical method for improving healthcare services in this field. Globally, cardiovascular diseases are a leading cause of deaths; however, they can be significantly reduced with early detection and prevention [12]. The authors Y. Yang, J. Li, and Y. Liu developed an Internet of Things (IoT)-based Virtual Doctor Robot for in-home healthcare as a novel approach to improve healthcare services by enabling patients to get medical advice and care from the comfort of their homes. IoT technology is used in this method to remotely monitor patients' health and provide personalised treatment recommendations [13]. IoT-based platforms the authors, M. Wang, H. Zhang, and Y. Zhou have developed a viable gadget for remote health monitoring and emergency response. It goes under the name of Virtual Doctor Robot. An artificial doctor robot employs wearable sensors, medical sensors, and other IoT devices to collect and analyse data from several sources in order to keep track on the patient's health [14]. The authors L. Zhang, X. Wang, and J. Li developed a Virtual Doctor Robot that is Internet of Things (IoT) enabled as a novel way to improve paediatric healthcare services. This virtual doctor robot employs IoT technology to collect and analyse data from various sources, including wearable sensors, medical sensors, and other IoT devices, in order to monitor the child's health [15]. The IoT-based Virtual Doctor Robot, developed by authors J. Liu, Y. Chen, and H. Chen, is a promising technology that uses IoT to collect and analyse data from many sources to keep a track on the health status of the elderly. In general, the development of the Internet of Things-based Virtual Doctor Robot for ageing healthcare services is a promising method for boosting healthcare services for senior patients and making medical treatment more patient-centred and accessible to all [16].



III. METHODOLOGY

In this project, the robot consists of two-parts:

- i. Dynamic part (Locomotive part)
- ii. Static part (Computational part)

The dynamic part of the robot is the heart of our project, which is the ESP32 Microcontroller, embedded in RUDRA 4.0. RUDRA 4.0 is the patented microcontroller board based on ESP32 microcontroller, of Vishwakarma Institute of Technology, Pune. The RUDRA board consists of an ESP32 chip that offers Bluetooth and Wi-Fi capabilities via its SPI/SDIO or I2C/UART interfaces. With the help of a variety of proprietary software, ESP32 manages to consume extremely little power. The Arduino IDE platform is used for coding the hardware. This robot consists of four 200 RPM DC Motors and two L298N Motor Drivers. The motors are integrated with the wheels for the mobility of the robot and the motor drivers act like an interface between the motors and the RUDRA board, and are used for controlling the motors, by altering the voltage. We use motor drivers to give high power to the motor by using a small voltage signal from a microcontroller or a control system. This robot can be controlled using an application that is created on MIT-App Inventor. A web application IDE previously made available by Google and currently upkept by the Massachusetts Institute of Technology is called MIT-App Inventor. Using this application, we connect our device (mobile phone) to the robot with the aid of the ESP32's built-in Bluetooth module. For connecting our device to the robot through this application, we need to enable the Location and Bluetooth facilities of our device. By enabling Bluetooth from both ends, our device is connected to the robot and using the virtual controller, we can control the robot. For enabling the ESP32 Bluetooth module, we require some functions present inside the "BluetoothSerial.h" library, using which we make sure we have successfully connected to the controller device.



Figure 1 - Console to control the robot

Components used:

1. ESP32 - ESP32 (here, mounted on RUDRA board) is highly integrated with built-in filters, power management modules, a low-noise receive amplifier, a power amplifier, and an RF balun. Through its SPI/SDIO or I2C/UART interfaces, an ESP32 can be connected to other systems to provide Wi-Fi and Bluetooth functionalities. With the help of a variety of proprietary software products, ESP32 manages to consume extremely little power.

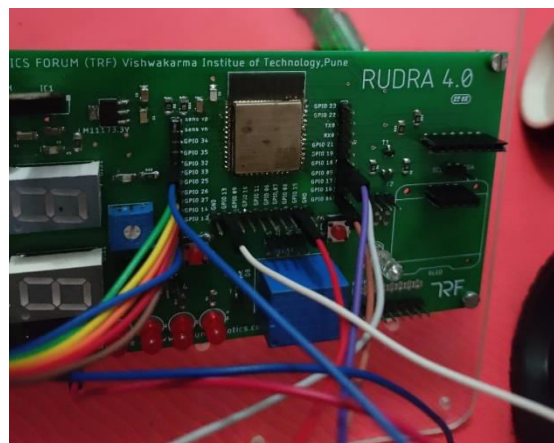


Figure 2 - ESP32 (RUDRA board)



- 2. Motors - 220 RPM motors typically have a voltage rating of 220 - 240V and a frequency of 50 - 60 Hz. They may have a power rating of 1/4 to 1/3 horsepower. The motor housing is typically made of Cast Iron or Aluminium for durability and heat dissipation. The stator and rotor are typically made of high-grade Steel or Copper. The motor may have a single or three-phase design, brushless or brushed design, an external fan for cooling and a built-in thermal overload protection to prevent overheating and damage.

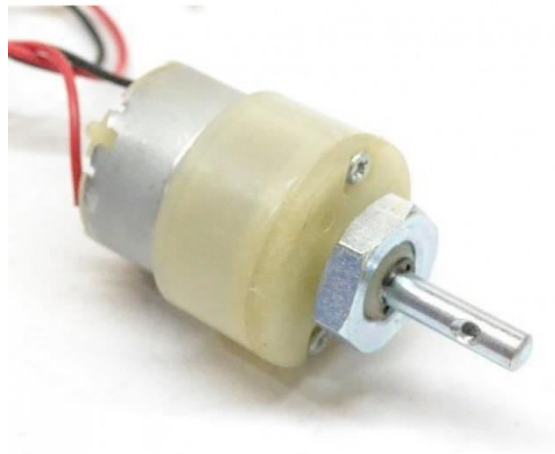


Figure 3 - 12V 200RPM DC Motor
Image courtesy – electronicscomp.com

- 3. Motor Drivers - Popular and adaptable dual H-bridge motor drivers like the L298N can be used to simultaneously control the speed and direction of two DC motors. It is commonly used in robotics and other applications where precise control of motors is required. The L298N motor driver is based on the L298 integrated circuit (IC), which provides the necessary drive and control signals for the motors. It can be used to drive motors with a voltage range of 5V to 35V and a maximum current of 2A per channel. The L298N motor driver also has a built-in voltage regulator, which enables its usage with a broad range of power supply voltages. It is a simple and reliable solution for controlling DC motors in a variety of applications.

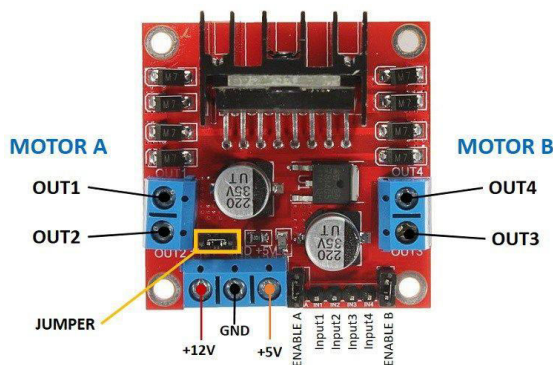


Figure 4 - L298N Motor Driver
Image courtesy – lohm.com

In the static part, we have integrated the sensors with the Arduino UNO, which are used to assess the patient's health indicators. In this robot, we are checking 2 basic human health parameters: SpO2 percentage and the Heart Rate of the patient. We have employed the MAX30100 Pulse Oximeter and Heart Rate Sensor to sense these parameters. The I2C platform-based, low-power MAX30100 sensor is a biometric sensor. The module includes the MAX30100 from Analog De-vices, a cutting-edge integrated pulse oximeter and heart rate sensor IC. To detect the Oxygen level (SpO2)



and Heart Rate (HR) signals, it includes two LEDs (i.e., Red and IR LED), a photodetector, enhanced optics, and analogue signal pro-cessing with minimal noise. This sensor consists of an IR LED and a Red LED, both with different wavelengths. The wavelength of the IR LED is 880 nm and the wavelength of the Red LED is 660 nm. For calculating the Heart Rate and SpO2 levels of the patient, the sensor calculates the amount of reflected light collected by the photodiode. So, when the patient keeps their finger on the sensor’s LEDs, the light is passed from the skin and depending on the amount of light absorbed and the amount of light reflected, the sensor calculates the patient’s Heart Rate and the SpO2 percentage. Now, the values measured by the sensors are displayed on the LCD display. We have integrated the MAX30100 sensor and a 16x2 LCD with Arduino UNO. The main component of the static part is the device (mobile phone) using which the patient can attend a video conference with the doctor.

Components used:

1. Arduino UNO - Built around the ATmega328P Microchip is an open-source microcontroller board known as the Arduino UNO. The boards' sets of digital and analogue input/output pins and other circuits can be used to interface with a variety of expansion boards (shields). Six analogue I/O pins, six digital I/O pins, and six PWM output pins are present on the board. A type-B USB cable can be used to program it using the Arduino IDE (Integrated Development Environment). It can be powered by a USB connection or an external 9-volt battery and supports voltages between 7 and 20 volts.

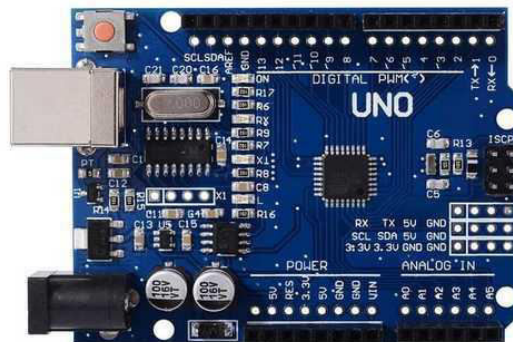


Figure 5 - Arduino UNO
Image courtesy – indiamart.com

2. MAX30100 Sensor - The Pulse Oximeter and Heart Rate Sensor, uses two different photodetectors to measure the oxygen saturation and Heart Rate of a per-son, respectively. The first photodetector, called the Red LED, emits red light, and measures the amount of light that is absorbed by the blood. The second photodetector, called the Infrared LED, emits an infrared light, and measures the amount of light that is transmitted through the blood. Both the photodetectors are connect-ed to an amplifier and an analogue-to-digital converter (ADC), which converts the signals into digital data that can be processed by the microcontroller. The micro-controller then uses algorithms to calculate the Heart Rate and Oxygen saturation based on the data from the photodetectors. By comparing the blood's absorption of red and infrared light, the Oxygen saturation can be determined, while the Heart Rate is calculated by detecting the changes in the amount of light absorbed by the blood as it flows through the arteries. The calculated oxygen saturation and Heart Rate are then displayed on the LCD screen or sent to a computer or smartphone via a Bluetooth connection. The MAX30100 Pulse Oximeter and Heart Rate Sensor also has a built-in alarm system that can alert the user if the oxygen saturation or Heart Rate falls outside of the normal range.

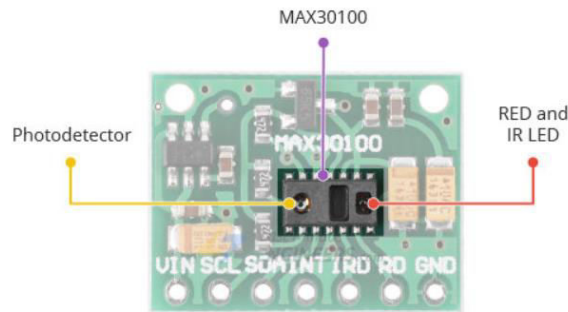


Figure 6 – MAX30100 sensor
Image courtesy - lastminuteengineers.com



Figure 7 - MAX30100 Sensor

3. LCD - One type of electronic display module, known as a Liquid Crystal Display (LCD), is utilised in a wide variety of circuits and devices. The working voltage for this LCD is between 4.7V and 5.3V. There are two rows, each of which can produce 16 characters. 16 pins are possible on an LCD. The parallel interface of LCDs requires simultaneous manipulation of multiple interface pins by the microcontroller in order to control the display.

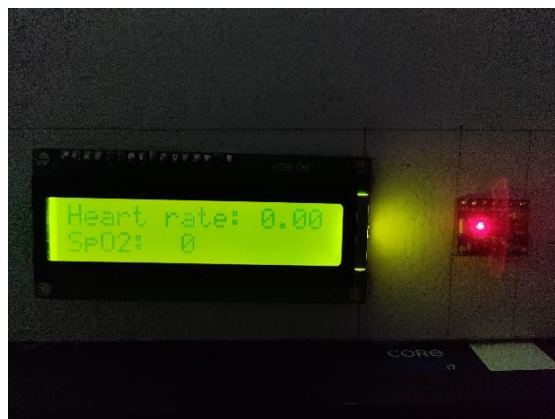


Figure 8 - LCD

IV. EXPERIMENTAL RESULTS

This robot can travel throughout the hospital through the specific designated path for the robot, which is sensed by it with the help of the Infrared Sensor. Currently, this robot is capable of sensing and measuring the Heart Rate and SpO2 level of the patient and display it on the LCD screen. Also, a mobile phone can be mounted on the robot, with the help of which we can initiate a video conference between the doctor and the patient.



V. CONCLUSION

In the future scope of this project, we would try to integrate more sensors to measure even more health parameters of the patients at the same time. Also, since this is a wireless robot, we can try to increase the range of its connectivity with its controller. We would also be working on making this robot slightly bigger in size, to provide a basic first aid kit along with the robot itself, which can provide the basic first aid services to the patients, then and there. Additionally, we will be trying to add a new feature to this robot, with the help of which it can call the doctor, or any nearby medical staff, immediately depending on the patient's state at the time or in an emergency.

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