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Design and development Virtual Doctor Robot for contactless monitoring of patients during COVID-19

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Abstract: The main objective of this paper is to design and develop a virtual doctor robot (VDR) that will operate on the command of the actual doctor available far away from the patient through new technology AI and IoT. It is not possible for doctors to be present everywhere and every time, especially in remote areas of India during COVID-19. As a result, in an emergency, many patients lose their lives because they couldn't reach the hospital on time or the doctor couldn't be available on time. In such a situation, virtual doctor robots play a vital role in healthcare with real-time data processing with machine learning algorithms. In this paper, technological innovation has created new opportunities to enhance doctor services without contact using robots that can assist patients in dealing with their illnesses and providing solutions. Virtual doctor robots can benefit healthcare by satisfying patients with more precise solutions. The virtual doctor robot design presented in this paper can rescue patients in remote areas during any pandemic like COVID-19. Through this virtual doctor robot, the doctors can observe and communicate with the patients through video calls and prescribe necessary medicines through scanner. The proposed VDR will help the doctors check the patient's pulse, body temperature, heart rate, etc. through different sensors mounted in the robot structure and send that data using the Wi-Fi network. The doctors will use an IoT-based panel to control and monitor the robot and patients. The control commands that are sent by the doctor to the VDR are sent online and the robot controller then receives these commands. The VDR also showcases other functions like alerting the battery status to remind one that the battery needs to be charged. It also stores the data related to diagnosed patients through cloud networking. The framework of VDR is based on an automated vehicle with a four-wheel drive for its movement and communication between the doctor and VDR is in real-time through the internet. This paper also discusses the future trends of Virtual Doctor robots for the health sector, humanoid robots for surgical help, and other activities of the healthcare sector.

Introduction

Historically, the demand for collaborative robots in the manufacturing industry has driven advancements in automation systems. The healthcare industry needs to accept new technologies. The finest solutions for helping and assisting doctors in medical tasks are robots. The healthcare industry's neglect of technological advancements has opened up new possibilities for improving service robots to help people manage their ailments and offer better solutions. Humanoid robots can improve patient happiness in healthcare by boosting it. They can also move dangerous materials and perform precision surgery in small spaces. This study extracted articles from three databases to systematically review the literature. This essay emphasizes humanoid robots' role in healthcare (Ozturkcan and Merdin-Uygur, 2022).

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The growth of technology has made our work and life easier. This advancement has helped researchers and scientists improve and transform medical equipment. Such leading technological progress has been widely used in many healthcare (Belle et al., 2015; Rong et al., 2020; Gao et al., 2018; Mehta and Pandit, 2018; Waring et al., 2020) services like treatment of a patient, monitoring of a patient, testing and also diagnosis. IOT has various applications in the medical field. IOT healthcare devices are available in the form of wearable fitness bands. Apart from this IOT (Patel et al., 2017) has been applied in various wirelessly connected equipment like blood pressure and heart monitoring cuffs. So far, advancements in healthcare (Akkas et al., 2020) have been possible by developing clinical sensors and implementing sensor networks in various hospitals. Mitra was also hired in Bangalore (Fortis, 2020) to screen each person entering a hospital in the manner described below. Mitra uses facial and speech recognition to check the medical, non-medical, and staff members for Covid-19 symptoms like fever or cough. The human healthcare personnel can keep a safe distance from symptomatic patients thanks to Mitra's assistance in identification and referral (Ozturkcan et al., 2022).

The combination of the sensors with the sensor network has played a very vivid role in delivering healthcare (Joseph et al., 2017; Rahmani et al., 2018) facilities from distant or remote locations. Because of such progress, various medical facilities have become more affordable and accessible. ML, AI, Big Data, cloud computing (Ali et al., 2018) and many such technologies have been employed to improve medical appliances. Recently Artificial intelligence (AI) is basically used in the early detection of cancer and such fatal diseases. Cloud computing (Abdelaziz et al., 2018) is used for storing patients' health records. The Virtual Doctor Robot (VDR) (Patel et al., 2017) also uses cloud services for the storing of medical records of the patients. Among all these technologies, the most convenient one that is popular in the medical domain is the Internet of Things (IOT) (Postolache et al., 2020). The Virtual Doctor Robot (Simoens et al., 2018) is a user-friendly health robotic machine that uses the Internet of things (IOT) (Priya et al., 2021) and cloud services (Casola et al., 2016).

Robots assisted in various pandemic-related tasks, including cleaning floors in grocery stores, strolling dogs, exhibiting homes to real estate agents, spraying disinfectants, and sorting items (Hayasaki, 2020). Assisting with contactless check-in and assisting with security at airports (Hornyak et al., 2020), recycling centers (Afanasyev et al., 2019), and airports (Mezes et al., 2022).

The doctors will use the IOT-based panel to control the robot, and the cloud services will help to keep track of the patients and their health records (Rai et al., 2021). The Virtual Doctor Robot (VDR) utilizes a blink app through which the doctor can control the robot from anywhere in the world with the help of the internet. The Blynk app provides all the sensors' data, i.e., the patient's pulse rate, heart rate, and body temperature, to the doctor. It draws power from the power bank module. Ultrasonic sensor has been used to protect the VDR from any kind of obstacle. The L298N motor driver has been used to run the motor in the robot. The VDR also consists of two batteries, one of 12V and the other of 7V. One nodeMCU is connected to the sensor, and the other is connected to the motor. The Blynk app has two types of cloud for the storage of data. One is the blynk cloud and the other is the one which we can privately run locally on the Blynk server. With the help of the Blynk app, the doctor can consult patients from anywhere in this world.

This paper is organized in the following manner: firstly, the introduction and uses of proposed topic and secondly, the Material and Methodology on basic humanoid and robotics in the literature review. Section 3 reviews the architecture and block diagram of the proposed IoT-based virtual doctor. The Hardware implementation and actual working model of the proposed VDR are in section 4. Finally, the proposed work of this article is concluded in the last section.

Materials, Components and Methodology for Proposed VDR

NodeMCU

The NodeMCU is an open-source IOT platform with firmware that runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and its hardware is based on ESP-12 module. It is a type of single-board

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microcontroller. It consists of 128 Kbytes memory and 4 Mbytes storage. Both its firmware and prototype board designs are open source. It uses a scripting language called Lua. It also uses several open-source projects like lua-cjson and SPIFFS. There are basically two versions of NodeMCU. The first one is NodeMCU version 0.9 and the second is NodeMCU version 1.0. The version 0.9 has ESP-12 and the other version 1.0 has ESP-12E, in which E indicates "Enhanced". The Virtual Doctor Robot connects the NodeMCU to a 7V battery. Two NodeMCU are used in the Virtual Doctor Robot (VDR). One NodeMCU is connected to the sensor and the other one is connected to the motor.

L298N Motor Driver

It is basically the controller which uses a H-Bridge to control the speed and directions of the DC motor easily. It is a high current and high voltage drive chip. It can control upto 4 DC Motors. When we want to rotate the left motor in one direction, we must apply a high pulse to IN1 and low pulse to IN2. To reverse the direction, we must apply a high pulse to IN2 and a low pulse to IN1. It consists of 78M05 Voltage Regulator, resistors, capacitors, Power LED, 5V jumper in an integrated circuit.

Blynk App

The Blynk app is a new platform that helps one build interfaces for controlling and monitoring the hardware components from Android and iOS devices. First user needs to download the Blynk app and then create a project dashboard and arrange buttons, graphs, sliders and other widgets onto the screen. It is like a digital dashboard in which we can create a graphic interface for the desired project. The Blynk app also provides a cloud service known as blynk cloud, or we can also locally run our private Blynk server. This app is used to control the NodeMCU, Raspberry Pi and Arduino with the help of the internet. It creates a Human Machine Interface by providing the exact address on the widgets. In the Virtual Doctor Robot, the doctor uses the Blynk app to consult patients from anywhere in this world. With the use of the Blynk app, data from the sensors, like the patient's pulse rate, heart rate, and body temperature, is sent to the doctor with the help of the internet. It also helps to store the data in the Blynk cloud or our private Blynk server.

Ultrasonic Sensor

Ultrasonic sensor consists of four pins. The first pin is Vcc, the last pin is the ground pin, it also has a trigger pin, the output pin, and an echo pin, the input pin. It consists of the transmitter and receiver. The Virtual Doctor Robot (VDR) ultrasonic sensor is used to protect the root from any obstacle (Fu et al., 2022).

Temperature Sensor

The temperature sensor is mainly used for the measurement of temperature. This is used in the Virtual Doctor Robot (VDR) for the measurement of the body temperature of the patient. The main principle for working any temperature sensor is the voltage across the diode terminals. It converts the input data to electronic data. It can measure the temperature directly or indirectly with or without making physical contact with the object (Bouchard et al., 2022).

Pulse Oximeter

The pulse oximeter is used in the Virtual Doctor Robot (VDR) for the measurement of the pulse rate of the patient. It is an electronic device that measures the saturation of oxygen carried in the red blood cells (Lee et al., 2022;) A normal person's oxygen level must be 95% or higher. The oxygen level helps the doctors determine whether the patient needs to receive supplemental oxygen.

Arduino (UNO)

Arduino UNO is used in various applications, mainly in robotics (Rai et al., 2022; Shuaib et al., 2020; Rusia et al., 2021). It is also used in home automation. It consists of a data transport port connected to the laptop or the mobile phone via OTG. It transfers the program from the laptop or phone to the arduino. It consists of a port from where a power supply is given. It consists of a microcontroller which is the main component of the arduino. It is also known as the brain of the microcontroller. Program is basically stored here only. It consists of 28 pins, of which the 14 pins are for digital input/output. Out of these 14 pins, 6 pins are analog and the other 6 pins are of PWM (Pulse Width Modulus). It consists of a reset button. The Wi-Fi Module and all the other components, like the ECG Sensor, Temperature Sensor, Pulse Oximeter, Ultrasonic Sensor are connected to the Arduino UNO.

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Block Diagram

The block diagram briefly overviews the Virtual Doctor Robot (VDR) and its components. It consists of a Wi-Fi module, two ECG Sensors, Pulse Oximeter, Ultrasonic Sensor and Temperature Sensor. All these are connected to the Arduino UNO. The Ultrasonic sensor protects the robot from any kind of obstacle. The basic proposed model of prototype VDR is shown in figure1 as a block diagram. In the proposed Model basic microcontroller board Arduino UNO was connected with all basic sensors like Pulse oximeter, ECG Sensors, temperature sensor and ultrasonic sensors for sensing different parameters such as temperature, SPO_2 Level, heart rate etc. of the patient and using Wi-fi module sent it to an actual doctor for further process.

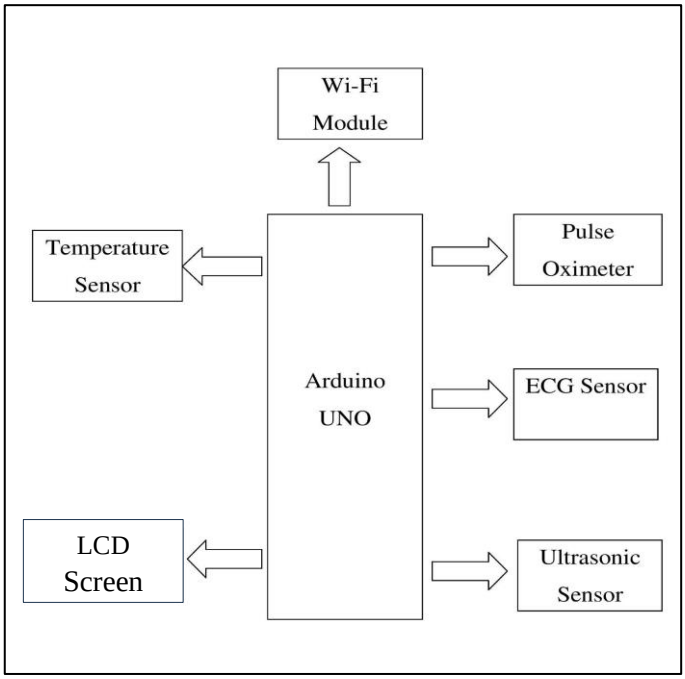

Figure 1. Block Diagram of proposed VDR model with sensors and Wi-fi Module

Setup & Performance

Initialy the proposed model are examined in the laboratory with the breadboard and component mentioned in the preceding paragraph to check the real-time applications. VDR basically measures the patient body temperature and oxygen level first using sensors mounted on the front of proposed model. The figure 2 shows the setup of the testing pulse and temperature sensor by Aurdino board and display the real data on the LED display. Simultaneously through the programming on Blynk app display the measured data on screen of the user or controller which can monitor the actual condition of the patient. Figure 3 shows the actual dashboard of implemented application during the simulation of the proposed VDR component. This application can be run on any desktop, Laptop, Tablet and Mobile phone. Using this application, the patient data can be recorded and stored in cloud for future purpose.

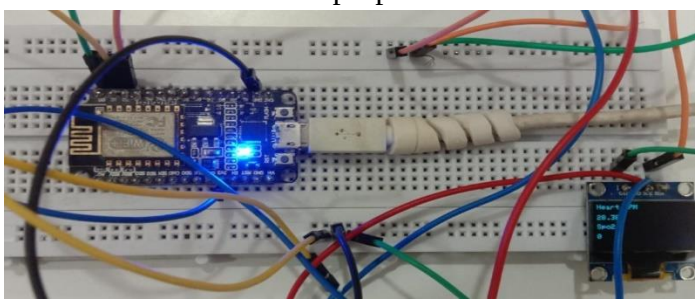

Figure 2.Setup of testing of LCD display with Aurdino UNO board and sensors

The robot controller uses wifi internet to function. Real-time commands are sent, and the robot actuators are activated to carry out the requested movement instructions. Additional root features include a battery status indication that serves as a reminder to charge batteries on schedule. The framework uses an autonomous vehicle with four wheels for a straightforward path. The robot also features a mounting for a phone or tablet as well as a regulating box for the hardware. To conduct live video calls, a tablet or portable device is used. To operate the robot, the specialist can use an IOT-based board. The robot regulator receives the control orders delivered through the Internet. The robot regulator utilizes WiFi for operation. They received orders in stages, and the robotic engines were activated to carry out the best development commands. The root also offers other functions, such as a battery status alert, to remind users to charge their batteries on schedule. The Virtual Doctor Robot is a piece of IoT and cloud-based consumer healthcare robot technology. Cloud computer services will help keep a record of the persons and health information, and doctors will control the robot via an Internet of Things panel.

The IoT-based software that powers VDR enables doctors to control the robot virtually from anywhere in the world via the internet known as the BlynkIt app.

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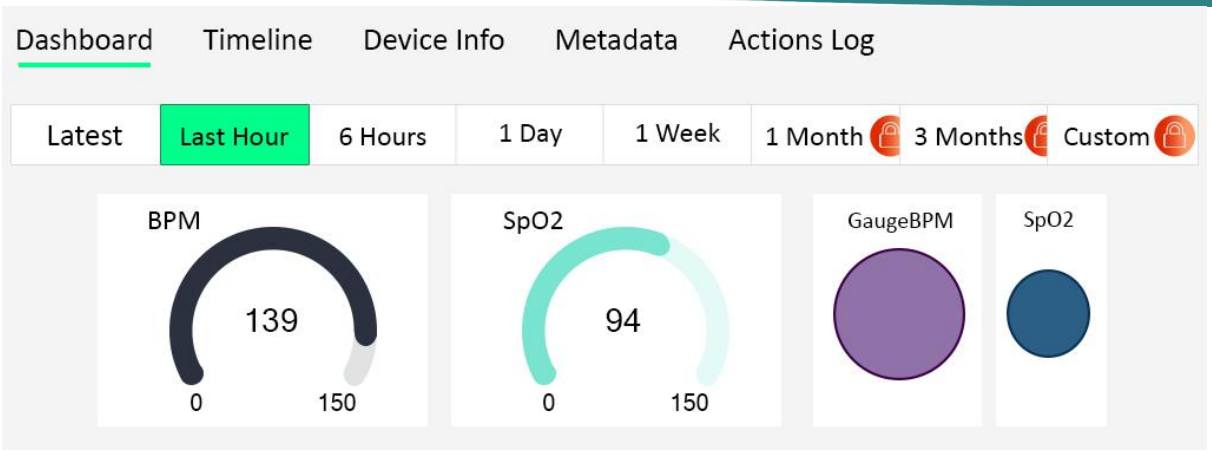

Figure 3. Software dashboard display of Bood Pressure Measurement (BPM) and SpO2 Level

It is like a digital dashboard in which we can create a graphic interface for our project. This app is responsible for all the communications that are made between the hardware and the smartphone. The Blynk app also provides us with its cloud service known as blynk cloud, or we can also locally run our private Blynk server. This app is used to control the NodeMCU, Raspberry Pi and Arduino with the help of the internet. It creates a Human Machine Interface by providing the exact address on the widgets. The Blynk app transmits all sensor data to the doctor, including the patient's heart rate, core temperature, and pulse. The portable power module powers 't'. A sensor using ultrasonic waves protected the VDR from any obstructions. Additionally, VDR warns the user of the battery's condition and lets them know that it needs to be charged, signaling that the time for battery charging has come. An L298N motor driver drove the robot's motor.

Results and Discussion

Virtual Doctor Robot consists of four wheels that help move the robot. Present model is based on wood and paper for the fabrication of VDR, as shown in figure 6. The VDR box's final structure, shown in the figures below, required various cabinet for the mounting circuits and the batteries used for the functioning of Virtual Doctor Robot and other components. Virtual Doctor Robot (VDR) also has a robotic base and supporting frames. The outer box is made of plywood. It consists of the temperature sensor for measuring temperature and the pulse oximeter for oxygen level detection and heart rate detection mounted on PCB as shown in figure 4. For simple navigation, the system uses a robotic car with four-wheel drive. The robot also has a controlling box with all other sensors and a microcontroller for the electronics functioning with Wi-fi module for communication of the robot as well as a mounting of a tablet or phone. Live video calls are held on a mobile device or tablet. The doctor may control the robot via an IOT-based panel and server through networking. The robot controller receives the control commands given online. The prototype of the proposed model is built with wood and electronics components and circuits, as shown in figure 4, figure 5 and figure 6 is used and modeled as a diagram of commercialized VDR with a wider LED screen. Further, VDR will be implemented with a high-resolution HD camera and all sensors mounted on iron or steel body with compact design and easy movement according to market demand. But it is currently in the innovation and testing stage, so it is available with the structure shown in Figure 6.

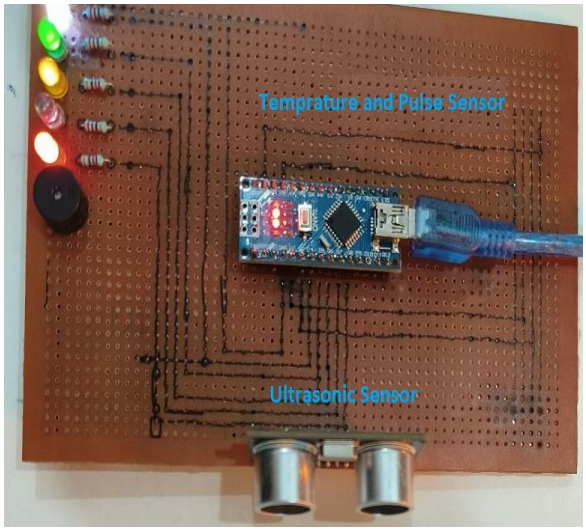

Figure 4. Ultrasonic, Temperature & Pulse

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Figure 5. Virtual Doctor Robot (Front sensor implementation on VDR View)

Figure 6. Final prototype Virtual Doctor Robot with display and sensors

The proposed VDR is compared with the Ozturkcan (2022) Humanoid service robots, which only gives the outline work and future perspective of humanoid in the health care system for various functions. But VDR actually reads patent conditions in real-time and processes simultaneously with available nearby doctors. The humanoid robot proposed by Mukherjee et al. (2022) for the helping hand of doctors in health care cannot perform data processing through IoT and cloud. The flow chart of AI-enabled Robot given in Denecke and Baudoin (2022) is implemented successfully in hardware and tested for some work in this paper.

There are various cases where people die because they weren't able to make it to the hospital on time or because the doctor wasn't available. As we face a pandemic COVID-19, the VDR could be of the most use. Without any contact, the doctor could check the patient and see the reports and keep track of his pulse, heart rate and body temperature. If the patient's condition worsens, the VDR will send the new pulse, heart, and temperature to the doctor. As we all know, during the COVID-19 pandemic, many died due to the lack of medical facilities or being in a remote location. This has happened all over the world. The Virtual Doctor Robot helps us properly treat the patient and maintain proper social distancing. Doctors can check the patients by video calls without making any contact with the patient unless and until there is a stable internet connection.

People in rural areas who couldn't consult doctors and receive proper medical care because of their remote location can now consult doctors with the help of Virtual Doctor Robot via video calls. Doctors can consult anyone and everyone from any remote or distant location unless and until there is a proper internet connection. Emergency patients can be treated on priority with the help of Virtual Doctor Robot (VDR). With the help of the blynk app, the doctor can receive all the data, i.e., the patient's health records from the sensor. The Blynk app also saves the patient's data in the Blynk cloud or the private Blynk server.

The Virtual Doctor Robot (VDR) is useful in all hospitals and clinics. Doctors can virtually keep track of their patient's health records and data. Doctors can virtually move around in operation theatres and around the patient's room. The Virtual Doctor Robot (VDR) is used in emergency centers. Doctors can see the patients via video calls and their reports. A great benefit of the Virtual Doctor Benefit (VDR) is in the rural areas where the doctors can't always go, or the patients don't have any kind of medical centers nearby. Another advantage of the Virtual Doctor Robot (VDR) is that it is very helpful for quarantine patients. Patients can consult doctors while being quarantined and doctors can get regular health records of the patient.

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Conclusion

Worldwide healthcare is facing short- and long-term issues, including demographic shifts, requests for higher quality, resource constraints, financial constraints and specially shortage of expert and intelligent doctors at the time and in remote areas. Robots, particularly Virtual Doctor and Humanoid robots, present prospects for overcoming some of these difficulties. The healthcare system has to be redesigned in the not-too-distant future to potentially include more Virtual and Intelligent Doctor Robots and humanoids in various positions to provide better support and service. The virtual doctor robot and Humanoid fully fill this void as doctors can't be present everywhere and at every time for all types of patients and emergencies. Patients in some remote locations can also access the doctors' reports, tests and medicine prescriptions using IoT and VDR. Because of the VDR the doctors too can access the medical records of their patients or test reports of the patient from a distant or remote location and suggest the medicine with instructions or send messages to the patient mobile. There are various cases where people die because they couldn't make it to the hospital on time or because the doctor wasn't unavailable. As such, a situation is frequently faced during the pandemic time COVID-19, where the proposed VDR could be fitted and helpful the most. Without any contact, the doctor could check the patient and observe the reports and keep track of his pulse, heart rate and body temperature. If the patient's condition worsens, The VDR will send the new pulse rate, heart rate, and temperature to the doctor. This way would lessen the disease spread along with the regular check-up of the patient and if the patient's condition worsens, the doctor will be able to see the immediate changes in the health record.

Conflict of interest

None

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