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Exploring the Effectiveness of IoT in Virtual Doctor Robot Systems

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Abstract

The design and development of a Virtual Doctor Robot (VDR) using Internet of Things technology is presented in this study with the goal of facilitating remote medical assistance. In light of the constraints associated with physical presence, especially in underprivileged areas like isolated parts of India during the COVID-19 pandemic, videoconferencing (VDR) is a viable means of bridging the gap between patients and physicians. The VDR makes accurate diagnostic and treatment suggestions possible by utilizing machine learning algorithms and real-time data processing. Important features include the ability to monitor vital signs using integrated sensors, communicate via video chats, and see patients remotely. Doctors can connect with patients and the robot seamlessly thanks to an IoT-based panel that facilitates control and monitoring. The VDR also has cloud-based patient record data storage and notifications regarding battery status. The doctor and the robot can communicate continuously thanks to real-time internet access, and the VDR's four-wheel drive autonomous vehicle architecture guarantees effective mobility. The study also addresses future trends, such as the possible use of humanoid robots to assist with surgery and other developments in the healthcare industry. The robot also features a controller box for circuits along with security camera. Patients are observed via the camera. The NODEMCU (esp-8266), L298N motor driver, DC motors, temperature sensor, and pulse oximeter are the necessary hardware components. The robot controller receives the internet directions. The robot controller is connected to the internet via Wi-Fi. Real-time instructions are received, and the robot motors are controlled to carry out the required movement commands. IoT and microcontrollers are used to monitor and control the entire system.

Keywords: VDR, IoT, NODEMCU, L298n motor driver, DC motors, temperature sensor, pulse oximeter

INTRODUCTION

In recent years, the convergence of technological innovation and healthcare has sparked a revolution in how medical services are delivered and managed. This transformation is driven by the pressing need to address the challenges facing the healthcare industry, ranging from rising healthcare costs and the growing burden of chronic diseases to disparities in access to quality care. At the forefront of this revolution are emerging technologies such as the Internet of Things (IoT), artificial intelligence (AI), and robotics, which hold immense promise for improving patient outcomes, enhancing the efficiency of healthcare delivery, and promoting sustainability in the healthcare ecosystem [1].

The existing healthcare system seamlessly integrates medical devices, sensors, and cutting-

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edge data analytics leveraging the power of the Internet of Things (IoT) [2]. Through wearable sensors and medical monitoring equipment, vital patient data is collected and meticulously analysed using advanced algorithms. Additionally, the system facilitates remote consultations via telemedicine, ensuring patient comfort and accessibility while upholding stringent standards for data security and interoperability with existing healthcare systems. Overall, this groundbreaking approach represents a significant leap forward in healthcare delivery, offering efficient, patient-centric solutions with the potential to revolutionize the healthcare industry [3].

While the current IoT-based virtual doctor robot system offers numerous benefits, including real-time monitoring and remote consultations [4], it also faces drawbacks stemming from its heavy reliance on technology. One notable limitation is the reduced level of human interaction, which may impact patient experience and satisfaction. Additionally, accessibility barriers may arise, hindering certain individuals from fully benefiting from the system's capabilities. Moreover, technical issues such as Wi-Fi connectivity issues, delays in data transmission, and limitations in battery capacity can impede the system's effectiveness and reliability.

The scope of research for IoT-based virtual doctor robots encompasses various critical dimensions essential for their development and optimization [5]. One key area of focus lies in data analytics and machine learning, where researchers explore advanced algorithms to analyse patient data effectively and improve decision-making processes. Additionally, there is a significant emphasis on telemedicine and remote consultations, aiming to enhance remote healthcare delivery and consultations for improved accessibility and convenience. Another essential aspect is user experience and human-computer interaction, where researchers strive to create intuitive interfaces and interactions to ensure seamless experiences for both patients and healthcare provider [6]. Furthermore, research in healthcare delivery models explores innovative approaches to integrate virtual doctor robots into existing systems for optimal efficacy. Lastly, addressing health equity and access disparities is paramount, ensuring that virtual doctor robot services are accessible and utilized equitably across diverse populations.

In the context of healthcare technology, the incorporation of advanced machine learning and artificial intelligence methodologies, exemplified by the Convolutional Neural Network (CNN) [7], represents a pivotal advancement for augmenting the functionalities of IoT-based virtual doctor robots. These technologies facilitate various applications within virtual doctor robots, including medical image analysis, predictive analytics, natural language processing (NLP), anomaly detection, and personalized medical assistance [8]. Predictive analytics leverage historical patient data and vital signs to forecast future health outcomes accurately. NLP algorithms improve the capacity of virtual medical robots to comprehend and react to patients' natural language inputs during teleconsultations or other interactions. Anomaly detection mechanisms enable real-time identification of deviations from normal patterns in patient data collected by IoT sensors. Moreover, ML algorithms can uncover hidden patterns and correlations in patient data, providing personalized medical insights that may elude human observers. These advancements underscore the potential of ML and AI technologies to revolutionize healthcare delivery through IoT-based virtual doctor robots [9].

EXAMINATION OF RELEVANT TEXTS

1. Ganesh *et al*. [2]: The purpose of this paper is to develop an automated system that can quickly connect patients with doctors, hospitals, or healthcare providers. This will help control the spread of diseases and reduce the growing death rates in rural areas.
2. Chaudhari *et al*. [8]: The Internet of Things (IoT) is seen as a promising framework due to its scalability, which facilitates consistent and dependable health monitoring worldwide. In this context, the authors previously proposed an IoT-based healthcare platform designed for remote monitoring of patients in critical conditions.
3. Ganesh *et al*. [10]: It has been observed that, as far as healthcare sector is concerned, IoT is far much efficient in providing much effective evaluation prior to traditional methods in hospital.

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For patients suffering from diabetes, it is very much mandatory to evaluate the condition of glucose on regular basis in which devices using IoT sensors like in wrist band could be more well organized than in traditional based method.

4. Alshehri and Muhammad [3]: The term "the remote delivery of healthcare services" sums up telemedicine. Although telemedicine carries with it numerous benefits, it has its downsides as well. Policymakers, payers, and providers all recognize that it can be challenging to stay on top of certain grey areas. Over the next 10 years, the sector will expand rapidly, but it will also provide both technological and practical problems.
5. Filho *et al*. [9]: When combined with health wearables, IoT can eliminate the need for hospital visits for routine medical problems. Additionally, this considerably lowers the costs of medical care for the patients. Additionally, by tracking the patient's health data over time via an application, doctors can prescribe required drugs. To comprehend how the used sensors functioned, a thorough analysis of the data was collected with regard to fluctuations in physical and environmental activity.
6. Hameed and Bajwa [7]: In this study, a portable physiological checking framework is displayed, which can constantly screen the patient’s heartbeat, temperature and other basic parameters of the room. We suggested a continuous monitoring and control device that uses Wi-Fi Module-based remote communication to save patient data on a server and screen the patient's condition.
7. Hossain and Hossain [5]: The majority of medical personal desired to control their assistance robot over the internet. Any paramedic can use a device called FASTele, a portable tele-echography robot, in emergency situations. A number of techniques have been developed for the PMS (Patient Monitoring System), non-contact infrared thermometer, digital thermometer, advanced healthcare, and smart healthcare.
8. Hamim *et al*. [6]: Associative cortices are activated more when there is multisensory integration, and this is beneficial for learning as well as neuronal plasticity and repair. Few studies have compared neurocognitive therapy to other rehabilitative methods; nevertheless, some promising research suggests that it can significantly improve upper-limb function, everyday activity capacity, and quality of life when compared to typical task-oriented training.
9. Singh *et al*. [4]: The foundation of IoRT applications may be an intelligent network architecture that is dynamically expanded and upgraded by edge nodes, which are produced by linked robotic objects. Artificial Intelligence (AI), Digital Twins (DT), Distributed Ledger Technologies (DLTs), Intelligent Connectivity, Distributed and Federated Edge/Cloud Computing, Virtual/Augmented Reality (VR/AR), and Swarm Technologies are all combined in the Internet of Robotics (IoRT).
10. Bhunia *et al*. [11]: Robots are now integrated as "things" and connect to other things over the Internet thanks to the development of the Internet of Things (IoT). It demonstrates, with robotics and Internet of Things, the long-term advantages of human beings in the healthcare industry, medical crises, e-health, etc. It is also necessary to talk about the adoption period, interactions, and potential issues. The ability of IoT to reconnect with many entities, such as devices, apps, and human interaction, provides an improved solution for the healthcare and medical industries.

METHODOLOGY

Node MCU: Serves as a crucial component for facilitating wireless connectivity and control functionalities. Leveraging its open-source IoT platform and firmware running on the ESP8266 Wi-Fi SoC, the NodeMCU enables seamless communication between various sensors and actuators within the system. With hardware based on the ESP-12 module, it functions as a single-board microcontroller, offering 128 kb of memory and 4 MB of storage capacity. Both its firmware and prototype board designs are open source, allowing for flexibility and customization in system development. The NodeMCU utilizes Lua, a scripting language, and integrates several open-source projects such as lua-cjson and SPIFFS for enhanced functionality. In the virtual doctor robot, two versions of NodeMCU are utilized: version 0.9 featuring ESP-12 and version 1.0 with ESP-12E, denoting "Enhanced". These NodeMCU units are essential for connecting sensors and motors, with one NodeMCU linked to the sensors and the other to the motor, facilitating efficient data acquisition and control operations within the system. Additionally, the NodeMCU is powered by a 7 V battery, ensuring mobility and autonomy for the virtual doctor robot.

L298N motor driver serves as a pivotal component within the IoT-based virtual doctor robot, functioning as a controller capable of regulating the speed and direction of DC motors via an H-Bridge configuration. This driver chip, which supports up to four DC motors concurrently, is distinguished by its capacity to manage large currents and voltages. It also makes precise motor control possible. Operational control of the motor direction is achieved through the manipulation of input signals: applying a high pulse to one input (IN1 or IN2) while grounding the other (IN2 or IN1) dictates the motor's rotational direction. The internal circuitry of the L298N driver includes essential components such as the 78M05 voltage regulator, resistors, capacitors, power LED, and a 5 V jumper, all integrated within a single chip architecture. This comprehensive design enables efficient and reliable motor control, essential for the seamless operation of the virtual doctor robot in healthcare applications [11].

Blynk app serves as a versatile platform integral to the IoT-based virtual doctor robot system, facilitating the creation of user interfaces for controlling and monitoring hardware components via Android and iOS devices. Upon installation, users initiate project creation within the Blynk app, configuring a dashboard layout comprising buttons, graphs, sliders, and other interactive widgets tailored to specific project requirements. Functioning akin to a digital dashboard, the app enables the creation of a graphical interface that intuitively interfaces with the underlying hardware components. Additionally, the Blynk app offers cloud services, including the Blynk cloud and the option to locally host a private Blynk server, providing flexibility in data storage and management. Leveraging the Blynk app, healthcare professionals utilize an Internet-enabled connection to remotely consult patients, accessing real-time data from sensors such as pulse rate, heart rate, and body temperature. Furthermore, the app facilitates data transmission and storage, allowing seamless integration with the Blynk cloud or private server for secure and centralized data management. In essence, the Blynk app serves as a pivotal component in enabling remote healthcare consultations and real-time monitoring within the virtual doctor robot system.

Ultrasonic sensor: integral to the architecture of the Virtual Doctor Robot (VDR), is characterized by its four-pin configuration. The sensor's pins include Vcc for supplying voltage, ground for electrical grounding, trigger for initiating ultrasonic wave transmission, and echo for receiving reflected signals. Functionally, the sensor comprises both a transmitter and a receiver unit, enabling it to emit ultrasonic pulses and detect their reflections. Within the VDR system, the ultrasonic sensor serves a critical role in obstacle detection and avoidance, contributing to the robot's navigational capabilities and ensuring safe and efficient operation in various environments [12].

Temperature sensor: employed within the Virtual Doctor Robot (VDR) system, functions as a vital component for accurately measuring ambient or body temperature. Operating on the principle of the voltage across the diode terminals, the sensor facilitates the conversion of temperature data into electronic signals. Utilizing either direct or indirect methods, the temperature sensor can measure temperature with or without physical contact with the object of interest. Within the VDR context, the temperature sensor plays a crucial role in monitoring and recording patient body temperature, contributing to the system's capability for real-time health assessment and patient care management [13].

Pulse oximeter: integrated within the Virtual Doctor Robot (VDR) system, functions as an essential tool for measuring the patient's pulse rate and oxygen saturation levels. Operating on electronic principles, the pulse oximeter measures the saturation of oxygen carried by red blood cells in the bloodstream. It measures variations in light absorption using optical sensors, which allows it to calculate the oxygen saturation level. In clinical settings, a normal oxygen saturation level typically ranges from 95% or higher, assisting healthcare providers in assessing the patient's respiratory status and determining the need for supplemental oxygen therapy. Within the VDR framework, the pulse oximeter enhances the system's capability for real-time health monitoring and enables timely intervention based on vital physiological parameters [14].

V380 Pro camera (Smart Camera) includes within the IoT-based Virtual Doctor Robot (VDR) system serves as a pivotal component for remote patient monitoring and healthcare delivery. This sophisticated camera system offers multifaceted functionality that extends beyond mere visual surveillance, playing a crucial role in collecting and transmitting vital signs of patients. Primarily, the V380 Pro camera utilizes its high-resolution imaging capabilities to capture detailed visual information about the patient's condition. Through live video streaming, the camera provides real-time monitoring of the patient's physical state, allowing healthcare professionals to observe movements, gestures, and physical characteristics remotely. These sensors can be strategically positioned within the camera's vicinity or connected wirelessly to the camera system, enabling seamless integration and synchronization of vital sign data with the video stream. Through the utilization of IoT technology, the V380 Pro camera can transmit the collected vital sign data in real-time to the VDR system's central processing unit, typically an Arduino UNO microcontroller board. This data transmission occurs over Wi-Fi or other internet-enabled communication protocols, ensuring rapid and reliable delivery of vital sign information to healthcare professionals. By leveraging the capabilities of the V380 Pro camera within the IoT-based VDR system, healthcare providers can remotely monitor patients' vital signs with unparalleled convenience and efficiency. This integrated approach to patient monitoring enhances the quality-of-care delivery, facilitates early detection of health issues, and enables timely intervention, ultimately contributing to improved patient outcomes and healthcare management [15, 6].

Arduino UNO: a versatile microcontroller platform, finds widespread application in robotics and home automation domains [16]. Facilitating data communication, the UNO features a data transport port that interfaces with laptops or mobile devices via USB OTG for program uploading. Additionally, it incorporates a power supply port for external power provision. Central to its functionality is the microcontroller, serving as the primary processing unit and program storage repository, often referred to as the microcontroller's "brain". With a total of 28 pins, the UNO provides 14 digital input/output pins, of which 6 are analogue and 6 are PWM (Pulse Width Modulation) pins. Notably, the UNO includes a reset button for system initialization and recovery. In the context of the Virtual Doctor Robot (VDR), the Arduino UNO acts as a central hub, facilitating the connection and coordination of various components, including the Wi-Fi module, ECG sensor, temperature sensor, pulse oximeter, and ultrasonic sensor, thereby enabling seamless integration and operation of the robotic system.

Block Diagram

Block diagram of flow of information of Virtual Robot is shown in Figure 1.

The NodeMCU serves as the central microcontroller unit responsible for interfacing with and managing all sensors integrated within the Virtual Doctor Robot (VDR) system. Power is supplied to the circuit through batteries, ensuring autonomous operation and mobility [1]. The L298N dual H-Bridge motor driver facilitates precise control over two DC motors, enabling simultaneous adjustment of speed and direction. These DC motors are connected to the robot's wheels, enabling movement as per the directives provided by the attending doctor.

The VDR incorporates a V380 Pro camera, serving as a pivotal component for remote patient monitoring. This camera features night vision capabilities, facilitating continuous patient surveillance during low-light conditions, thereby supporting hospital staff during night duties. Additionally, the camera is equipped with an inbuilt microphone and speaker, enabling bidirectional audio communication between the doctor and patient. This functionality enables the doctor to provide real-time suggestions and instructions to patients, enhancing the quality of remote consultation.

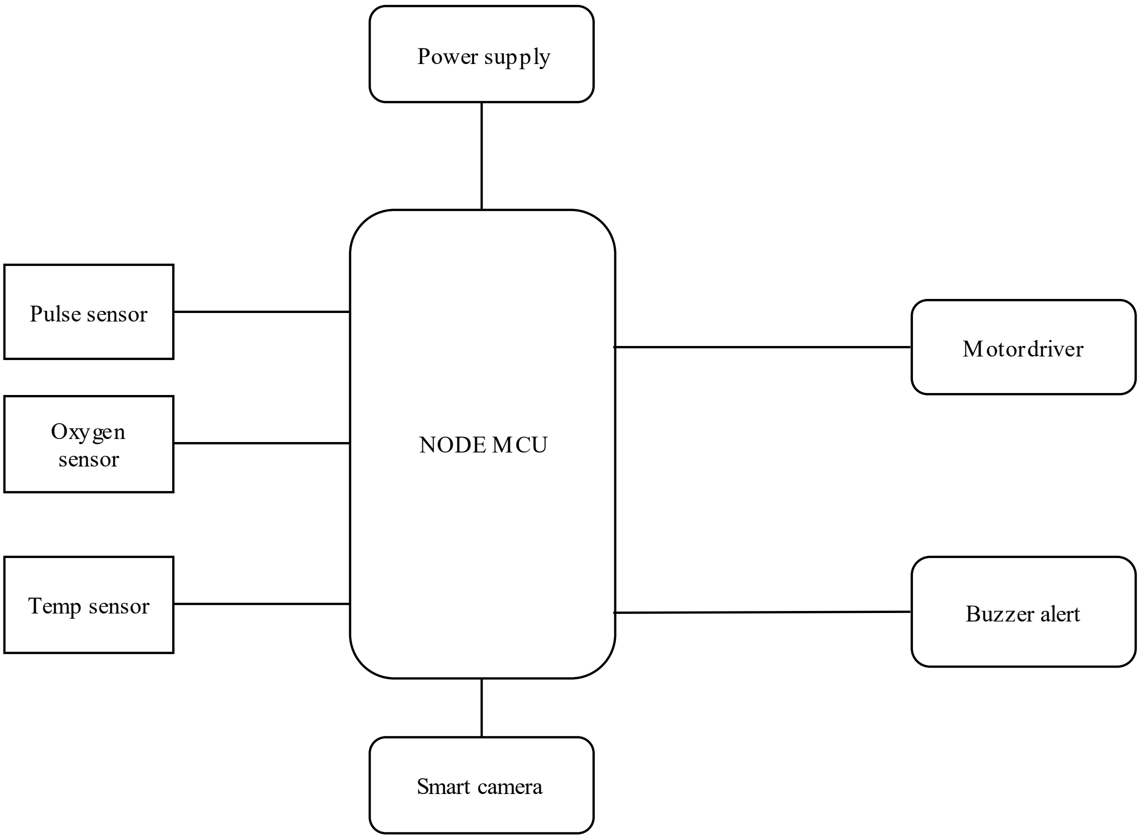


Figure 1. Block diagram of virtual robot.

An emergency push button is integrated into the VDR system, serving as a critical safety feature. Upon activation, this button triggers a buzzer alert, ensuring prompt attention and assistance in case of emergencies. The doctor can seamlessly control the robot's movements and functionalities through an IoT-based control panel, enabling remote operation from any location with internet connectivity.

Operational communication between the control panel and the robot controller is facilitated over Wi-Fi internet, ensuring real-time transmission of directives. The robot's motors receive these directives instantaneously, allowing for swift and precise execution of movement commands. Overall, the VDR system is meticulously designed to offer comprehensive control and monitoring capabilities, leveraging advanced microcontroller and IoT technologies to enhance healthcare delivery and patient care management.

RESULTS AND DISCUSSION

The Virtual Doctor Robot (VDR), powered by IoT technology, provides remote healthcare support, particularly in areas with limited access. It employs machine learning, real-time data analysis, and built-in sensors to track vital signs and enable video consultations. The robot includes cloud-based storage, real-time interaction, and autonomous movement, improving healthcare accessibility. Through a meticulous analysis and interpretation of the data and outcomes obtained, this section aims to shed light on the project's effectiveness, feasibility, and impact on healthcare delivery.

Software

Coding involved in software setup is shown in Figure 2.

This Arduino code controls a smart scar as shown in 3(b) using an ESP8266 microcontroller and the Blynk IoT platform. It includes libraries for ESP8266 Wi-Fi and Blynk, defines motor pins, sets up Wi-Fi credentials, and initializes Blynk.


```
#define BLYNK_PRINT Serial
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>

// Define the motor pins
#define ENA D0
#define IN1 D1
#define IN2 D2
#define IN3 D3
#define IN4 D4
#define ENB D5

// Variables for the Blynk widget values
int x = 50;
int y = 50;
int Speed;

char auth[] = "hb7CLWnRCDuPtoMjGBJU1YeWDdhEWRN8";
char ssid[] = "Redmi 10 Prime"; //Enter your WIFI name
char pass[] = "pickkachu01"; //Enter your WIFI passowrd


void setup() {
  Serial.begin(9600);
  //Set the motor pins as output pins
  pinMode(ENA, OUTPUT);
  pinMode(IN1, OUTPUT);
  pinMode(IN2, OUTPUT);
  pinMode(IN3, OUTPUT);
  pinMode(IN4, OUTPUT);

void smartcar() {
  if (y > 70) {
    carForward();
    Serial.println("carForward");
  } else if (y < 30) {
    carBackward();
    Serial.println("carBackward");
  } else if (x < 30) {
    carLeft();
    Serial.println("carLeft");
  } else if (x > 70) {
    carRight();
    Serial.println("carRight");
  } else if (x < 70 && x > 30 && y < 70 && y > 30) {
    carStop();
    Serial.println("carstop");
  }
}
void loop() {
  Blynk.run();// Run the blynk function
  smartcar();// Call the main function
}

/*****Motor movement functions******/
void carForward() {
  analogWrite(ENA, Speed);
  analogWrite(ENB, Speed);
  digitalWrite(IN1, LOW);
  digitalWrite(IN2, HIGH);
```

Figure 2. Software setup.

The code reads joystick and slider values from Blynk widgets and adjusts motor speed and direction accordingly. The smart car function interprets joystick values to determine car movement: which are forward, backward, left, right, or stop. Motor movement functions such as (carForward(), carBackward(), carLeft(), carRight(), carStop()) control motor direction and speed using pulse-width modulation (PWM) on motor enable pins.

In summary, this code allows remote control of a smart car as shown in 3(b) via the Blynk app, providing intuitive joystick and slider interfaces for users to adjust speed and direction.

Hardware

Hardware kit is shown in Figure 3.

Proceeding forward: In this case, the robot has to proceed forward when the line is in between the two sensors and both sensors are on a white surface facing upward. In order to propel the robot ahead, this requires the rotation of both motors. Both motors should, however, rotate in the opposite direction because of how our arrangement has the motors arranged. However, we will refer to the motors as spinning forward for convenience.

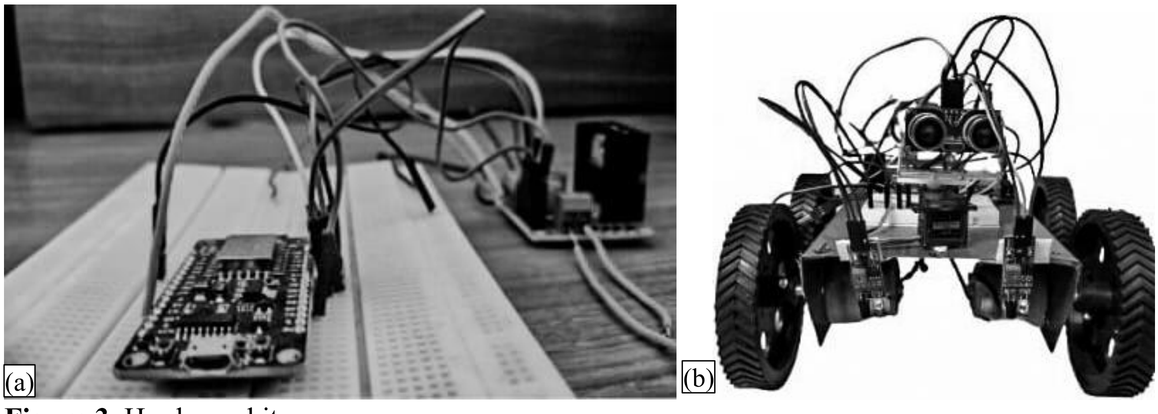
Turning left: In this case, the right sensor is on the white part of the reference line, while the left sensor is on top of the dark reference line and so detects the black reference line and signals the microcontroller. Given that the left sensor is sending a signal, the robot should turn left. Consequently, the left motor rotates backward while the right motor rotates forward. After that, the robot turns to the left.

Turning right: The robot should turn right in this situation, even though it is the same as the left example in that just the right sensor is present. To turn the robot in the proper direction, the left motor rotates forward; to turn it in the other direction, the right motor rotates backward.

To stop: Because both sensors are on top of the line and are able to detect the black line at the same time, the microcontroller is programmed to interpret this as a reason to stop the process. Consequently, the robot's two motors are shut off, preventing it from moving.

Integrating Blynk Cloud for Remote Health Monitoring

The Blynk cloud receives the data that is read from the sensors, allowing doctors to keep an eye on their patients' health. The sensor data is gathered and sent to the Blynk cloud platform, which includes vital patient health parameters including body temperature, blood oxygen saturation, and heart rate. This allows for real-time remote monitoring and assessment of patients' health problems by medical professionals, allowing for timely intervention and individualized care management. Health Parameters Result on Blynk Software is shown in Figure 4.



(a) (b)

Figure 3. Hardware kit.

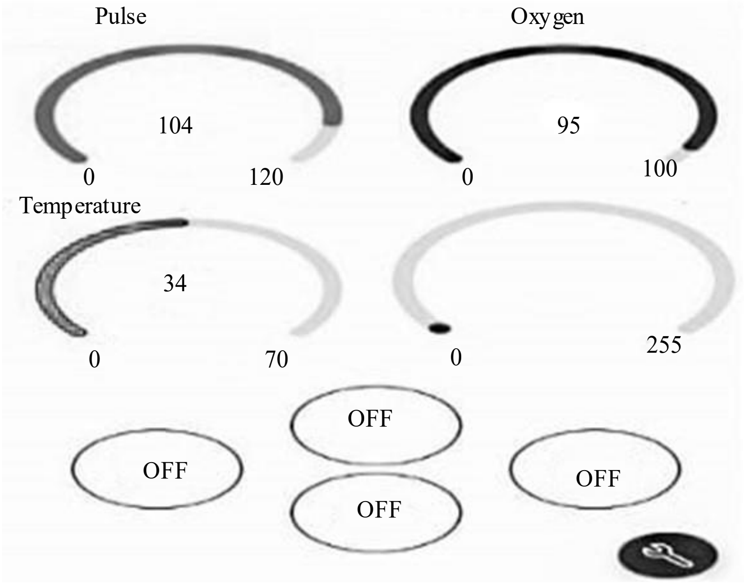


Figure 4. Health parameters result on Blynk software.

The results of the IoT-based Virtual Doctor Robot project demonstrate the successful implementation of a sophisticated remote patient monitoring and consultation system. Through the integration of various sensors, microcontrollers, and IoT technologies, the Virtual Doctor Robot offers comprehensive capabilities for capturing vital patient data, facilitating remote consultations, and enabling timely medical interventions.

1. *Sensor integration*: The project successfully integrated multiple sensors, including ECG sensors, a pulse oximeter, a temperature sensor, an ultrasonic sensor, and a V380 Pro camera. These sensors collectively capture essential patient parameters such as heart rate, blood oxygen saturation levels, body temperature, and environmental obstacles.
2. *Wireless connectivity*: Utilizing Wi-Fi connectivity, the Virtual Doctor Robot establishes a seamless connection with healthcare professionals, enabling real-time transmission of patient data and facilitating remote consultations. The wireless communication ensures flexibility and accessibility, allowing doctors to monitor patients from any location with internet access.
3. *Remote consultation interface*: The project incorporates the Blynk app as a user-friendly interface for controlling the Virtual Doctor Robot and accessing patient data. Healthcare professionals can remotely monitor patient vital signs, communicate with patients via audiovisual interfaces, and provide medical guidance in real-time.
4. *Emergency alert system:* The inclusion of an emergency push button provides an additional layer of safety, allowing patients to trigger an alert in case of medical emergencies. The buzzer alert system ensures prompt attention from healthcare providers, enhancing patient safety and facilitating rapid response to critical situations.
5. *Real-time monitoring and analysis*: With the ability to collect and transmit patient data in real-time, the Virtual Doctor Robot enables continuous monitoring and analysis of vital signs. Healthcare professionals can assess patient health status remotely, identify anomalies or abnormalities, and intervene promptly when necessary.
6. *Scalability and adaptability*: The Virtual Doctor Robot's modular architecture facilitates scalability and adaption to various healthcare environments and patient requirements. To expand the system's capabilities and meet changing medical needs, other sensors or features can be added with ease.

All things considered, the outcomes show how successful and revolutionary the Internet of Things-based Virtual Doctor Robot may be in transforming healthcare delivery.

By leveraging advanced technologies and wireless connectivity, the system empowers healthcare professionals to provide personalized, efficient, and accessible medical care, ultimately improving patient outcomes and enhancing the quality of healthcare services.

CONCLUSION

The convergence of technology and healthcare has ushered in a new era of patient-centric care delivery, marked by innovations such as the Internet of Things (IoT) and robotics. The IoT-based Virtual Doctor Robot represents a significant advancement in this paradigm, offering a comprehensive solution for remote patient monitoring and consultation. Through the integration of sensors, microcontrollers, and wireless connectivity, the Virtual Doctor Robot enables healthcare professionals to monitor vital patient parameters in real-time, facilitating timely interventions and personalized care management. The successful implementation of the Virtual Doctor Robot project underscores its potential to revolutionize healthcare delivery. By leveraging IoT technologies, the system provides a seamless platform for capturing and transmitting vital patient data to healthcare professionals via the Blynk cloud platform. This enables remote consultations, ensuring accessibility and convenience for both patients and doctors. Furthermore, the inclusion of an emergency alert system enhances patient safety, allowing for prompt responses to medical emergencies. The project's outcomes show how well wireless networking, sensor integration, and real-time monitoring capabilities work. Healthcare professionals can obtain important insights into patients' health state through ongoing data collection and analysis, enabling preventative measures and individualized treatment regimens. Additionally, the Virtual Doctor Robot's modular architecture allows for scalability and customization to a variety of healthcare settings, making it a flexible tool for meeting changing medical demands. In conclusion, the IoT-based Virtual Doctor Robot is a promising approach for boosting healthcare delivery and improving patient outcomes. By harnessing the power of technology, this innovative system empowers healthcare professionals to deliver high-quality, personalized care to patients, irrespective of geographical barriers. As we continue to advance in the field of healthcare technology, the Virtual Doctor Robot stands as a testament to the transformative potential of IoT and robotics in shaping the future of healthcare.

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