International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 3 Volume No.7 May - June – 2023
DOI:10.46647/ijetms.2023.v07i03.111 ISSN: 2581-4621

IoT – based Robot for Medical Assistant and Teleconsultation

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ABSTRACT
The COVID-19 pandemic has brought significant changes to the way clinicians interact with patients, with the implementation of measures like personal protective equipment, social distancing, and triage facilities. These measures aim to protect healthcare professionals and minimize the transmission of infection. However, despite these precautions, medical personnel still face a high risk of exposure, leading to a shortage of essential workforce during the pandemic. To address this challenge, medical assistant robots controlled by clinicians are introduced to enable a dynamic evaluation process within hospitals. The telehealth systems are mounted on robotic platforms, allowing them to move between patients, rooms, or wards in a hospital setting. By utilizing a temperature sensor and a pulse-oximeter sensor, the robot examines the vital signs such as skin temperature, pulse rate, and blood oxygen saturation of patients. Whenever any of these levels deviate from the normal range, the system promptly notifies hospital management and provides the required triaging assistance. Additionally, the robot scans the patient's RFID card to schedule an appointment with the clinician, streamlining the entire process through a responsive application.
Keywords— Medical robot, Internet of Things (IoT), triage, telemedicine

1. Introduction

The pandemic has presented an unprecedented and formidable challenge for hospitals and healthcare professionals worldwide. This global health crisis has thrust the healthcare industry into a state of emergency, pushing its capacity to the limit and necessitating swift adaptations to ensure the safety of both patients and healthcare workers. The surge in demand for healthcare services has created difficulties in screening and triaging patients. With the pandemic, healthcare facilities have had to implement new screening and triage protocols to identify and isolate patients with Covid-19 symptoms. Healthcare professionals are at a higher risk of infection due to their close contact with infected individuals. This has required significant resources and has sometimes led to delays in the patient flow process. In the face of overwhelming patient volumes, limited resources, and the need for stringent infection control measures, hospitals have sought innovative solutions to overcome these difficulties and deliver effective healthcare services.
The Internet of Things (IoT) can play a significant role in enhancing the capabilities and functionalities of medical assistant robots. By integrating IoT technologies, medical assistant robots can become more connected, intelligent, and efficient.

2. Objectives

This paper aims to design and develop a medical assistant robot to improve healthcare processes and enhance patient care. The key objectives of the paper include:

- Minimizing the risk of infection transmission by reducing direct contact between healthcare professionals and patients is crucial during a pandemic.

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- Medical assistant robots can be programmed to automate routine tasks and alleviate the burden on healthcare staff, who may be overwhelmed during a pandemic.
- To provide remote consultation and monitoring, enabling healthcare professionals to reach and care for a larger number of patients without compromising social distancing guidelines.
- The robot must enhance triage processes, quickly identifying and prioritizing patients based on symptoms, which is crucial during a pandemic when there is a surge in patient volumes.
- To help with the integration of existing electronic health record systems, providing seamless communication between healthcare providers, patients, and the scheduling system, streamlining the overall appointment management process.
- To assist in maintaining infection control protocols by performing tasks such as disinfection and sterilization, reducing the risk of cross-contamination in healthcare facilities.

By accomplishing these objectives, the IoT-based medical assistant robot aims to contribute to improved healthcare efficiency, enhanced patient experience, and better utilization of healthcare resources.

3. Literature Survey

The authors [1] proposed a gadget containing a processing section that takes input data, processes the data and then produces output. The proposed IOT system was able to monitor the human body temperature, SpO2 levels, and heartbeat rate of the patients with the help of sensors. The upkeep and automatic observation are done by the intervention of IoT that are accustomed transfer and retrieving information to the internet, a mobile app is used to monitor the sensor readings and sensor data is stored on the ThingSpeak cloud.

The paper [2] provides an innovative model and design for a semi-humanoid robot that could possibly be applied in a medical setting. The robot has a robotic arm with five degrees of freedom that can do pick-and-place operations. MoveIt helps to view the robot's pick and place capabilities.

The authors [3] provide background information on the study and examine some earlier related efforts in order to identify suitable collaboration for the development of additional pertinent devices and systems. An IoT-Based Medicine Reminder and Medicine Providing System, Automatic Hand Sanitizer, and IoT-Based Physiological Parameters Observing System are developed using the suggested methodology. These systems include a direct one-to-one server-based communication method and an end-user Android app maintaining system.

The paper [4] demonstrated the ROS (Robot Operating System) simulation of a multifunctional medical assistance robot. The ROS environment effectively mimics and depicts this intelligent robot. The suite of open-source robotics middleware is called Robot Operating System (ROS).

The authors [5] presented a robotic system intended for logistics and disinfection in a COVID-19 medical treatment facility. The system is distinguished by interaction capabilities and autonomous navigation. The article discusses experimental findings regarding the robot's ability to navigate in open spaces and engage in productive tasks with medical personnel in a clinical setting.

By creating an Autonomous Smart Medical Assistant Robot for contactless preliminary patient testing, the authors [6] suggested an innovative means to reduce touch and interaction between doctors and patients for preliminary tests that can be completed autonomously. For the robot's design and testing in this paper, Autodesk Fusion 360 software was utilized along with the Arduino IDE for programming and control. The robot may bring additional medical items to the doctor and the patients and can even serve as a source of support for patients.

The authors [7] assembled an IOT-based medical assistant robot for patient monitoring, which assisted in their design of a virtual doctor robot that allows a physician to interact with the medical robot virtually and even converse with others present as required. The author outlines the study's historical backdrop in addition to reviewing some previous similar research that contributed in the creation of relevant technologies. For easy navigation, the technology employs an IOT-based physiological indicator evaluation system and a robot automobile with four-wheel drive. The robot also contains a sensor control box with an installation for a camera screen.

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4. Proposed System

Medical assistant robots are devices that are designed to assist healthcare professionals in various aspects of patient care. These robots can interact with patients and execute out a variety of duties since they are outfitted with imaging equipment, sensors, and other cutting-edge technology. One of the primary advantages of medical assistant robots is that they can aid in the reduction of workload of healthcare professionals, freeing up more time for them to focus on other important tasks. Additionally, these robots can help to improve patient outcomes by providing more accurate and consistent care, reducing the risk of human error. They are meant to augment the capabilities of healthcare teams, improve patient care, and enhance overall efficiency in healthcare delivery.

a) Automating Patient Triage: The robot is equipped with advanced sensing and data collection capabilities to efficiently triage patients, gather relevant information, and direct them to the appropriate areas within the healthcare facility.

b) Assisting in Vital Signs Monitoring: The robot incorporates sensors for measuring vital signs, such as pulse-oximeter, heart rate, and temperature sensors, to provide real-time data to healthcare providers and facilitate remote patient monitoring.

c) Enhancing Communication: The robot act as a communication interface between patients and healthcare providers, allowing for seamless information exchange, and appointment reminders and aiding in teleconsultation.

d) Optimizing Workflow and Resource Allocation: By analyzing patient flow, wait times, and resource utilization, the robot will help to identify bottlenecks and inefficiencies in the healthcare system, enabling administrators to make informed decisions and optimize workflow.

e) Ensuring Patient Safety and Comfort: The robot is designed to navigate safely through healthcare environments, avoiding obstacles and ensuring patient safety. It will also prioritize patient comfort and provide a friendly and approachable interface.

f) Integrating with Backend Systems: The robot will be capable of integrating with backend systems, and appointment scheduling software, to facilitate seamless data exchange and streamline administrative processes.

5. Methodology and Implementation

The mobile robotic system is flexible and can operate both in an indoor and outdoor hospital setting. In an outdoor hospital setting, the robot checks the vital signs that include skin temperature, breathing rate, pulse rate, and blood oxygen saturation of the patients using a temperature sensor and a pulse-oximeter sensor. The sensors slide in and out of the sensing unit to measure the readings and are disinfected by the presence of UV-C light once the data is updated in the cloud. The system alerts the hospital management and the patient when any of the levels are below or above the normal range. The robot also schedules an appointment with the clinician upon scanning the RFID card of the patient, the entire process is done using a responsive application. In an indoor hospital setting, the clinician controls the chassis to move along the ward, the clinician can control the sensing unit, and can conduct a triage interview via the integrated video link on the mobile phone mounted.

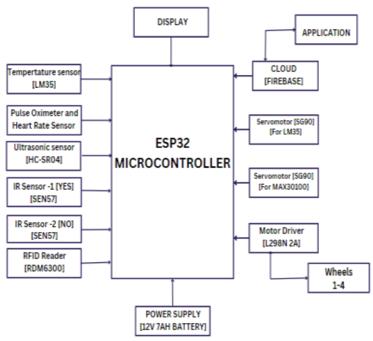

Fig 1: Block diagram of the Robot

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Fig 1 shows the block diagram which consists of an array of sensors that helps provide timely information and statistics to the end user. All the sensors are connected to the microcontroller which acts as the control unit of the system. The framework utilizes an automated vehicle with 4-wheel drive for simple routes. The robot likewise incorporates a regulator box for hardware containing the sensing unit and a mounting to hold a cell phone.

a) Sensing Unit: The IoT system includes a temperature sensor and a pulse-oximeter & heart-rate sensor to check the vital signs of the patient and provide the required triaging needed. The system is also automated with the presence of UVC light of 200-280 nm to disinfect the areas of contact to prevent the transmission of bacteria/viruses. The Sensing Unit is enclosed to optimize the sterilization process of the sensors. In this system, triaging is based on SpO2 levels, and it is an effective method to assess the severity of a patient's condition and prioritize their care. SpO2, or peripheral oxygen saturation, is a measure of the oxygen saturation level in a patient's blood. The Ultrasonic sensor helps in sensing human presence and the IR sensors are used for patient interaction.

Patients are provided with RFID cards or wristbands embedded with RFID chips. These chips contain unique identification information associated with the patient's medical records. RFID readers are installed on the front side of the robot. This technology helps in appointment scheduling. Automated appointment verification and real-time updates simplify administrative tasks for healthcare staff, allowing them to focus more on patient care.

b) Control Unit: The ESP32 receives the data sent by the temperature sensor and compares it with the normal body temperature. The control unit pushes the data into the Firebase database and the necessary response action is triggered. When the temperature of the individual is more than 98.6F, the pulse-oximeter sensor slides out of the sensing unit to measure the spO2 levels and the heartbeat rate. The recommended triaging facility is then given to the symptomatic individual.

c) Response Unit: The Response unit is used for processing triaging actions and scheduling appointments. The microcontroller triggers the response action according to the data from the Firebase database. Upon scheduling appointments, the patient's medical history and its contents are mailed to both the hospital management and the clinician. Once the indoor mode of the application is activated, the process of teleconsultation takes place along with ward sanitization. The clinician, through a website, can control the robotic chassis and also check the vital signs of the patient remotely.

6. Results

6.1 Mobile Application

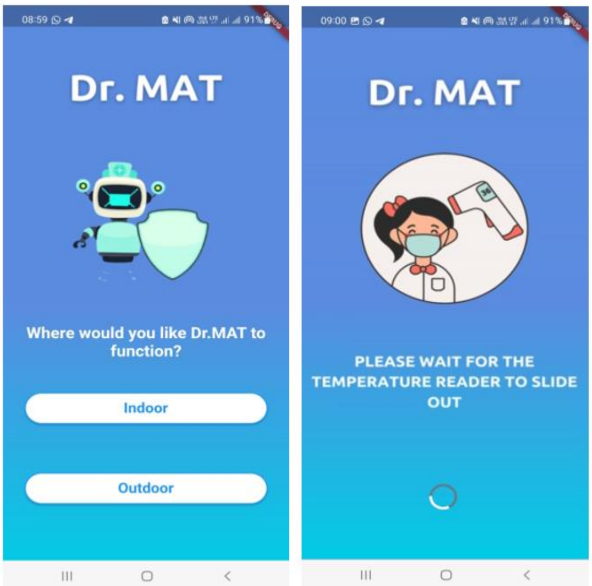

Fig 2 : Mobile Application for patient interaction

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Fig 2 shows the mobile application which acts as an interface between the clinician and the patient. The application has two modes – Outdoor and Indoor, the data is updated in the backend database and the application displays the next page according to the response.

6.2 Website application for remote monitoring

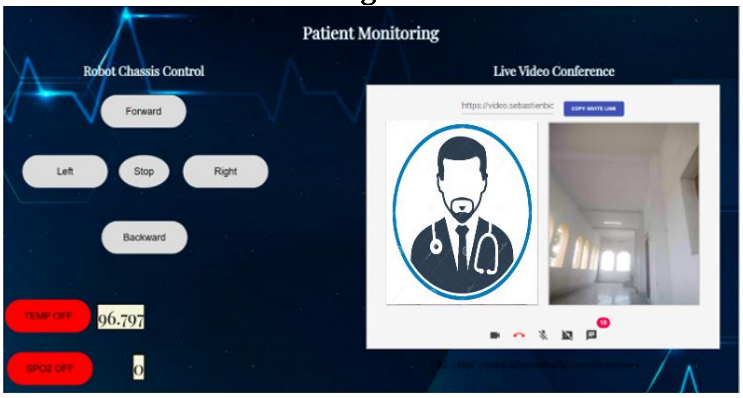

Fig 3 : Website for teleconsultation and remote monitoring

Fig 3 shows the website application which has a secure video conferencing feature that enables users to have real-time consultations with healthcare professionals. The website also consists of features for remote vital sign monitoring and controls for robotic chassis.

6.3 Structure of Medical Assistant Robot

Fig 4 : Structure of the robot

Fig 4 shows the structure of the robot. The robot's base provides stability and mobility. It includes wheels for movement, along with motors or actuators to enable navigation. The body of the robot houses the internal components and electronics. A sturdy and adjustable mount is attached to the top of the robot's body to securely hold the mobile phone. The phone's screen displays the developed application for triaging and appointment scheduling facilities.

CONCLUSION

Medical assistant robots have helped reduce the exposure of healthcare workers to infected patients, minimizing the risk of transmission. Medical assistant robots equipped with video conferencing capabilities have facilitated teleconsultation between patients and healthcare professionals. Remote

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vital sign monitoring helps minimize physical contact, conserves personal protective equipment (PPE), and reduces the need for frequent in-person visits. These robots are equipped with ultraviolet (UV) light mechanisms to sanitize hospital rooms, equipment, and surfaces. This technology helps in reducing the risk of infection by eliminating pathogens, including the COVID-19 virus, from the environment. On the whole, medical assistant robots have the capability to completely revolutionize the healthcare sector by enhancing patient care, minimizing expenditures, and driving productivity.
Medical assistant robots can evolve to incorporate advanced diagnostic capabilities. With advancements in artificial intelligence and machine learning, these robots can be programmed to analyze medical data, interpret diagnostic images, and assist healthcare professionals in making accurate and timely diagnoses.

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