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SMART MEDICAL ASSIST BOT: REVOLUTIONIZING PATIENT CARE IN ISOLATED HOSPITAL WARDS

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Abstract: In hospitals, preliminary health assessments are typically performed by doctors, involving direct physical contact with patients. This practice not only exposes healthcare workers to potential infectious diseases but also consumes valuable time that could be better spent on critical cases. Routine checks, which could be automated, often contribute to longer patient wait times and reduced overall efficiency in hospital operations. The COVID-19 pandemic has further emphasized the importance of minimizing human-to-human contact, with the World Health Organization (WHO) advocating for social distancing and contactless interaction to prevent the spread of the virus. This situation highlights a pressing need for innovative solutions that maintain high-quality care while reducing direct physical contact. This project addresses the challenge by developing an Autonomous Smart Medical Assistant Robot capable of performing contactless preliminary health testing. Designed to automate routine assessments, the robot significantly reduces doctors' workload, improves hospital workflow, and enhances patient management. It has been precisely designed and simulated using Autodesk Fusion 360, ensuring mechanical accuracy, while its control system is programmed using the Arduino IDE, allowing seamless integration of health-monitoring sensors and autonomous functionality. Beyond health assessments, the robot also provides emotional support to patients and can be used for the transport of medical supplies between healthcare providers and patients. This multifunctional capability not only enhances safety by limiting unnecessary exposure but also introduces operational efficiency and emotional care into medical settings. The implementation of this robot represents a step toward smarter, safer, and more compassionate healthcare environments.

Keywords- Autonomous Medical Robot, Contactless Health Testing, Smart Medical Assistant, Healthcare Robotics, Arduino-based Robot, Hospital Automation

1. INTRODUCTION

Combining Artificial Intelligence (AI) with the Internet of Things (IoT) leads to the development of smart robotic systems capable of autonomous decision-making, intelligent interaction, and adaptive behavior. These advanced robots are designed to go beyond basic automation, enabling them to learn from historical data, recognize patterns in patient behavior, and respond intelligently to real-time situations. For example, such a robot can remind a patient to take their medication, detect irregularities in vital signs, or alert medical staff if a patient becomes unresponsive, thereby enhancing both safety and care quality.

The integration of AI and IoT relies on several key technologies. Microcontrollers such as Arduino and Raspberry Pi play a central role in controlling robotic functions and integrating various sensors. These microcontrollers act as the brain of the system, managing data input and executing programmed tasks. IoT sensors are embedded to monitor a range of health metrics, including temperature, pulse, and motion. These sensors continuously gather data, which is then processed by the robot to assess the patient's condition. Additionally, cameras and microphones enable two-way remote communication, allowing healthcare providers to visually and audibly interact with patients from a distance. This is particularly useful for monitoring isolated or immobile patients, as it allows timely interventions without requiring physical presence. Cloud platforms and mobile applications further enhance the system by offering real-time data visualization, remote control capabilities, and secure data storage. Medical staff can access patient data anytime, facilitating informed decision-making.

Machine learning algorithms form the intelligence core of these robotic systems. By analyzing historical and real-time data, these algorithms can predict potential health events such as falls, seizures, or changes in vital signs. The robot can then prioritize tasks accordingly—for instance, delivering medication if abnormal health trends are detected or alerting emergency services in critical situations. This dynamic decision-making ensures that patient care is not only responsive but also personalized and proactive. Overall, the synergy between AI and IoT transforms traditional healthcare robots into intelligent assistants that enhance efficiency, reduce manual workload, and provide adaptive support tailored to individual patient needs. This combination enables robots to operate in complex, real-world healthcare environments, improving the quality of care, patient safety, and operational efficiency in hospitals and home care settings.

2. LITERATURE SURVEY

Chen et al. (2025) introduced USPilot, an autonomous robotic ultrasound assistant that integrates a Large Language Model (LLM) with a Graph Neural Network (GNN). Through a semantic router and text-attributed graph (TaG), the system interprets user instructions and autonomously performs ultrasound scans. It addresses the shortage of professional sonographers and enables natural language interaction. Despite its effectiveness, limitations include reliance on large LLMs, hardware constraints, and misinterpretation of nuanced human feedback.

Sun et al. (2025) developed a CMOS camera-equipped infrared thermography (IRT) system that remotely measures vital signs like respiration, heart rate, and facial skin temperature. It uses a logistic regression model to predict infection risk in about 10 seconds, showing better accuracy than fever-based methods. Although fast and non-invasive, its accuracy may be affected by environmental and individual factors.

Khan et al. (2025) designed ALICE, an AI-based healthcare assistant robot that performs administrative tasks, assists patients with navigation, answers FAQs, and provides medical education. It reduces staff workload and enhances patient experience but depends on a well-maintained knowledge base and struggles with complex or ambiguous inquiries.

Hasan et al. (2024) presented an Autonomous Medical Assistive Robot tailored for medical camps. It uses the Robot Operating System (ROS), SLAM, and the A* algorithm for navigation, while MobileNetV2 ensures mask compliance. It features floor sanitization and an AI-driven chatbot for patient assistance. Its limitations include voice recognition issues in noisy environments and infrastructure requirements.

Xu et al. (2024) introduced an Ultrasound Embodied Intelligence system that enables surgical robots to perform autonomous scans using LLMs and natural language instructions. This "think-observe-execute" model adapts to real-time patient movements, increasing ultrasound accuracy. However, its success depends on data quality and brings challenges related to privacy and algorithmic bias.

Shaik et al. (2023) reviewed AI's role in Remote Patient Monitoring (RPM). AI enhances early health deterioration detection, personalization through federated learning, and behavior modeling via reinforcement learning. Despite its potential, RPM systems face challenges in data privacy, infrastructure readiness, and system integration.

Zhang et al. (2023) developed Pi-ViMo, a mmWave radar-based system for non-contact vital sign monitoring. Using a physiology-inspired model and signal processing, it accurately tracks respiration and heart rate regardless of subject movement, though performance may decline in noisy or crowded settings.

Zhang et al. (2023) also introduced Wital, a WiFi-based non-line-of-sight (NLOS) system for contactless vital sign monitoring. Utilizing commercial devices, it achieves high accuracy by separating vital signs from motion disturbances. While cost-effective and scalable, Wital's reliability is susceptible to signal interference.

Warmbein et al. (2023) explored the adoption of mobilization robots in hospitals. Through interviews, they identified barriers like staff resistance and training gaps, and enablers such as leadership support and clear communication. Their findings underscore the importance of addressing organizational culture in successful tech adoption.

Sun et al. (2022) proposed a remote photoplethysmography (rPPG) system using facial videos for vital sign monitoring. Its hybrid processing technique improves accuracy and reduces contact risks, but its effectiveness can vary with lighting, motion, and skin tone.

Huang et al. (2022) introduced Dr. Spot, a quadruped robot designed for contactless patient monitoring. Equipped with IR/RGB cameras, it supports telemedicine and tracks vital signs from up to 5 meters. Though effective in minimizing contact, it depends on teleoperation and favorable conditions.

Rohmetra et al. (2021) examined AI-powered remote monitoring during COVID-19. Using everyday devices, their framework reduces infection risks and improves continuous observation. However, data privacy, model reliability, and AI bias remain key challenges.

3. PROPOSED SYSTEM

The proposed system introduces an Autonomous Smart Medical Assistant Robot designed to conduct contactless preliminary health assessments in hospital settings. This innovation aims to reduce direct interactions between healthcare professionals and patients, minimizing the risk of disease transmission and optimizing the use of medical staff. The robot autonomously measures vital signs such as body temperature, heart rate, and oxygen saturation using non-invasive sensors, ensuring safety and efficiency.

The mechanical design and structural simulations of the robot are created using Autodesk Fusion 360, ensuring a durable and ergonomic build. Control systems and programming are implemented via the Arduino IDE, allowing seamless integration of hardware components. The robot features several key components, including an RFID module for patient identification, a MAX30105 sensor for pulse and oximetry readings, and an MLX90614 infrared sensor for accurate, contactless temperature measurements. Additionally, it is equipped with a touchscreen interface for user interaction and a compartment for transporting medical supplies, enhancing its functionality within the hospital.

This system automates routine health checks and logistical tasks, promoting social distancing and streamlining hospital operations. By reducing direct contact between healthcare providers and patients, the robot improves patient throughput, reduces the workload of medical staff, and supports enhanced infection control measures, which are particularly crucial during pandemics. The proposed robot not only boosts hospital efficiency but also plays a pivotal role in minimizing healthcare-associated risks, offering a practical solution to meet both patient care needs and safety requirements in dynamic hospital environments.

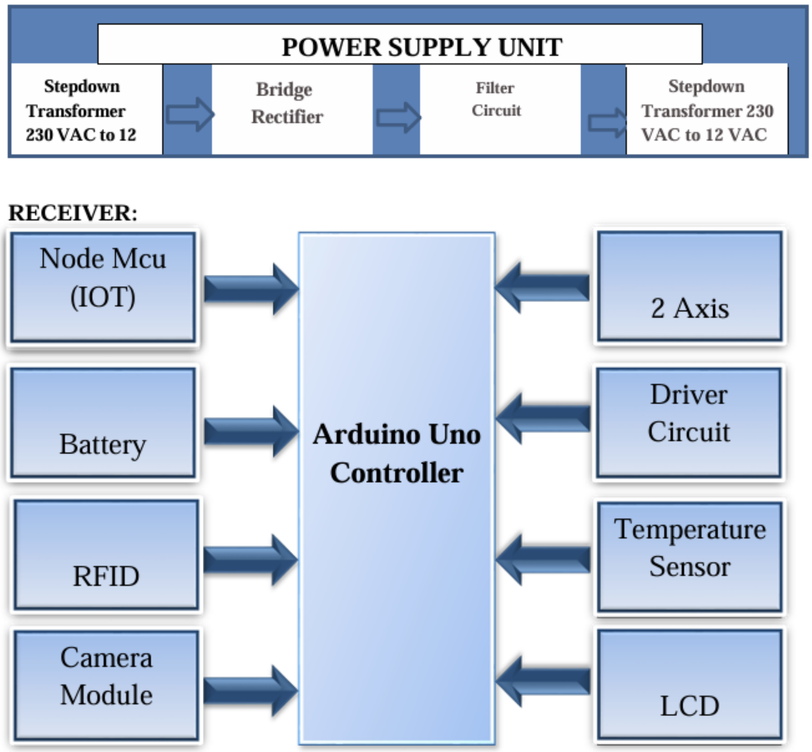


Figure 1: SYSTEM ARCHITECTURE OF SMART MEDICAL ASSIST BOT REVOLUTIONIZING PATIENT CARE IN ISOLATED HOSPITAL WARDS

4. RESULTS AND DISCUSSION

The Medical Assist Robot successfully demonstrated its capabilities through real-time data sensing, processing, and transmission in a simulated hospital environment. The robot effectively showcased its functionality, with several key features performing as expected during testing. Upon scanning the RFID tag, the robot correctly identified the patient and initiated the health monitoring procedure, capturing vital signs such as temperature, heart rate, and oxygen saturation. These readings were displayed on the robot's LCD screen for immediate reference.

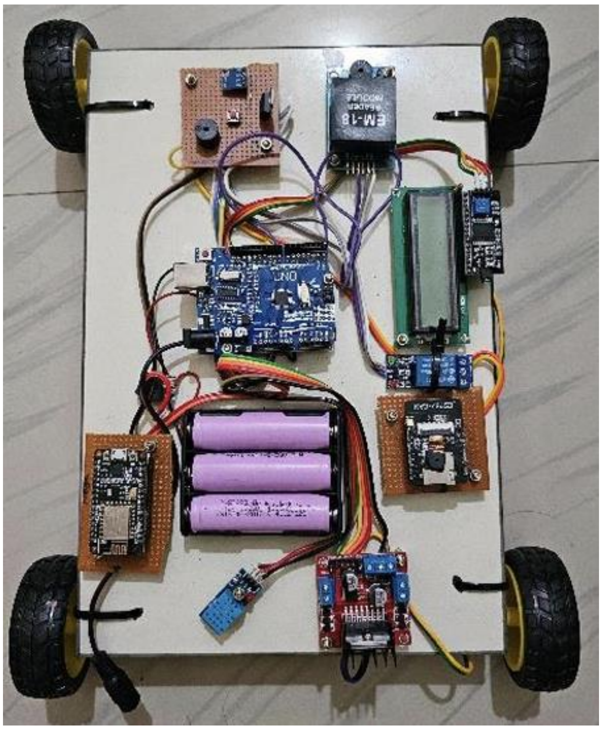
The deployment of the Medical Assist Robot in isolated hospital wards successfully achieved its goal of contactless initial health assessments and essential supply deliveries. Using non-invasive sensors like the MLX90614 (temperature) and MAX30105 (heart rate and oxygen saturation), the robot accurately monitored patient vital signs. The data was displayed on an LCD screen and wirelessly transmitted via the NodeMCU module to a remote monitoring interface for healthcare staff to track patient health.

The robot utilized RFID technology for accurate patient identification, ensuring secure and traceable logging of health data. Its autonomous mobility enabled it to navigate isolated wards, delivering medical supplies and equipment with minimal human interaction, thus reducing exposure risk for healthcare workers. Sensor accuracy was verified to be within medical standards: temperature readings had a ±0.2°C accuracy, heart rate was accurate within ±2 BPM, and oxygen saturation (SpO_2) readings had a ±1.5% margin of error.

In addition, the robot responded to instructions within 2 seconds, featured a 4–6 hour battery backup, and could trigger alarms in emergency situations, such as when oxygen saturation levels dropped below critical thresholds. The robot's deployment significantly improved operational efficiency, ensured patient safety, and demonstrated the potential of IoT and AI integration in real-time medical care, particularly in pandemic-sensitive environments where minimizing human contact is crucial.

Simultaneously, the vital sign data was transmitted to a remote monitoring system using the NodeMCU module and Wi-Fi connectivity. This enabled healthcare personnel to monitor and log patient data in real time through a centralized dashboard. The system formatted the data into logs containing patient ID, vital signs, and timestamps, ensuring organized and traceable data management. This feature allows for effective tracking and ensures that the patient's health information is well-documented for future reference.

In the event of an emergency—such as when oxygen saturation fell below 90%—the robot's alert system was triggered. It activated an inbuilt buzzer and displayed a visual alert, immediately drawing the attention of medical staff to the critical condition. This real-time response ensures that urgent medical attention can be provided promptly.



Additionally, the robot's mobility system was tested by responding to commands for moving along predetermined paths. It demonstrated its ability to navigate the hospital environment efficiently, delivering medical supplies to specified locations. This added mobility enhances its role in hospital logistics, ensuring that medical items reach the right places without requiring manual intervention.

The outcomes of the testing, both through physical interaction via the LCD screen and digitally through IoT transmission, were consistent, reliable, and timely. The successful performance of the robot highlighted its potential to improve healthcare provision, particularly in remote hospital wards. By automating routine tasks such as monitoring vital signs and delivering medical supplies, the robot not only enhances the efficiency of hospital operations but also contributes to patient safety by providing quick responses in emergency situations. This technology holds great promise for improving healthcare quality while minimizing the risks associated with direct patient contact.

5. CONCLUSION

In this study, we provided a comprehensive overview of the diverse types of robots deployed within clinical settings, particularly focusing on their roles in SARS-CoV-2 contaminated zones. The primary objective was to serve as an informative resource on current advancements in the medical sector, emphasizing how robotic technologies have been instrumental in combating highly infectious diseases like COVID-19. Our analysis revealed that robots have been utilized across various domains in healthcare during the pandemic. These include disinfection tasks, delivery of medications and supplies, patient monitoring, and facilitating telemedicine to minimize direct human contact. Such applications not only reduced the exposure risk for healthcare workers but also alleviated their workload, allowing them to focus more on critical patient care. For instance, disinfection robots employing UV-C light have been effective in sterilizing hospital environments, thereby curbing the spread of the virus. However, a notable limitation of our study is its primary focus on scientific publications, which may have led to the exclusion of innovative industrial applications of healthcare robots. The rapid evolution of robotic technologies in the private sector, especially during the pandemic, suggests that there are practical implementations that remain undocumented in academic literature. The post-pandemic healthcare landscape appears to be increasingly reliant on robotic solutions to prevent human-to-human transmission. Developed markets have witnessed a surge in demand for medical robots, attributed to their functional advantages and efficacy in limiting the spread of SARS-CoV-2. This trend indicates a potential acceleration in the adoption of robotics. The integration of robotics into healthcare systems represents a transformative shift towards more resilient and efficient medical infrastructures.

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