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Smart Hospital Patient Monitoring Robot using ESP8266

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Abstract : The increasing demand for efficient healthcare services and the need to reduce direct physical interaction between medical staff and patients have encouraged the adoption of smart hospital technologies. This project presents a Smart Hospital Patient Monitoring Robot Using ESP8266, designed to support remote doctor–patient interaction and basic patient monitoring in hospital environments.

The proposed system is developed using a ESP8266 as the central processing unit

due to its compact size, low cost, and sufficient processing capability for web-based applications. A display, integrated camera, microphone, and speaker enable real-time two-way audio and video communication, allowing doctors to observe patients and provide medical guidance remotely. The robot is implemented as a trolley-
mounted unit to ensure operational safety and ease of movement within hospital

wards, avoiding the complexity of fully autonomous navigation.

System control and monitoring are performed through a web-based dashboard, eliminating the need for dedicated mobile applications. Real-time communication is achieved using Jitsi Meet, an open-source WebRTC-based platform that operates directly through a web browser, improving scalability and maintainability while reducing development cost.

The proposed system helps reduce the workload of healthcare professionals, minimizes unnecessary physical movement, and lowers the risk of infection transmission. By utilizing low-cost hardware components and open-source software, the solution offers an economical alternative to commercial telepresence systems. Overall, the project demonstrates a practical, scalable, and cost-effective approach for integrating telepresence-assisted patient monitoring in modern healthcare environments.

INTRODUCTION:

Modern healthcare systems face increasing challenges due to rising patient numbers, limited availability of medical professionals, and the need to ensure safety within hospital environments. Doctors and nursing staff are often required to move frequently between wards for routine monitoring and consultations, which increases workload and, in certain cases, the risk of infection transmission. These challenges have created a strong demand for smart hospital solutions that enable efficient patient monitoring and remote interaction.

Recent advancements in embedded systems, Internet of Things (IoT), and web-based

communication technologies have made it possible to develop intelligent healthcare support systems at a relatively low cost. ESP8266 –based platforms, in particular, offer a flexible and affordable solution for implementing smart medical applications due to their compact size, processing capability, and support for open-source software.

This project proposes a Smart Hospital Patient Monitoring Robot Using ESP8266 to

facilitate remote doctor–patient interaction within hospital wards. The system enables real-time audio and video communication between patients and doctors
using a web-based interface, reducing the need for continuous physical presence. The robot is designed as a trolley-mounted unit to ensure safety, simplicity, and ease of deployment in clinical environments.

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By combining low-cost hardware with open-source communication tools, the

proposed system aims to improve healthcare efficiency, reduce staff workload, and enhance patient experience. The solution is intended for practical implementation in hospitals as well as academic research in smart healthcare technologies.

LITERATURE REVIEW :

The expanding role of telemedicine in healthcare has led to numerous implementations of remote patient interaction and monitoring systems. Early telemedicine frameworks focused primarily on software-based solutions, enabling remote consultations through smartphones, tablets, or computers. Such platforms, including proprietary video conferencing systems and custom mobile applications, provide basic two-way communication between doctors and patients. Although effective in connecting geographically distant users, these approaches are often limited in hospital environments because they depend on patient access to personal devices and do not integrate with dedicated in-ward hardware systems.

To address these limitations, researchers and developers have explored robotic telepresence solutions within clinical settings. Commercial telepresence robots, such as those used in large hospital networks, integrate autonomous navigation with audiovisual communication, allowing healthcare professionals to virtually traverse wards and interact with patients. While these systems offer enhanced mobility and richer interaction capabilities, their high cost, complexity, and dependency on proprietary software make them less suitable for small and medium healthcare facilities or academic projects. Moreover, autonomous navigation increases system complexity and introduces safety concerns in crowded hospital environments.

Several academic efforts have also utilized low-cost embedded platforms like Arduino, ESP8266, and microcontroller variants to implement basic patient monitoring systems. These solutions typically focus on sensing physiological parameters such as heart rate, temperature, or oxygen saturation and transmitting data for remote viewing. Although valuable for health tracking, they often lack real-time bidirectional audio and video communication, which is crucial for interactive consultation. Other ESP32–based implementations support web interfaces for remote control, but they either rely on static devices (e.g., fixed bedside units) or mobile teleconferencing setups that are not optimized for use within dynamic hospital wards.

The Smart Hospital Patient Monitoring Robot Using ESP8266 builds upon these existing works by combining cost-effective hardware and open-source communication technology to enable real-time two-way audio and video interaction in a dedicated in-ward unit. Unlike commercial telepresence robots, this system prioritizes simplicity, safety, and affordability, eliminating autonomous navigation and emphasizing stable, trolley-based deployment. By leveraging web-based communication frameworks such as WebRTC through browser interfaces, the project offers a scalable and maintainable alternative to both proprietary telepresence systems and sensor-only monitoring solutions.

METHODOLOGY (MATERIALS AND METHODS)

The methodology of this project focuses on designing and implementing a cost-effective smart hospital patient monitoring robot that enables remote doctor–patient interaction using readily available hardware and open-source software. The overall approach is divided into hardware selection and integration, software development, communication setup, and system operation workflow.

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HARDWARE COMPONENTS AND SETUP

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SOFTWARE TOOLS AND COMMUNICATION FRAMEWORK

The ESP8266 operates on a Linux-based operating system, configured to automatically launch required services at startup. A web-based dashboard, developed using Node-RED or standard web technologies, is used for system control and monitoring. This dashboard allows healthcare staff to initiate video calls, manage system status, and access the interface remotely through a browser.

For real-time audio and video communication, Jitsi Meet, an open-source WebRTC-based platform, is employed. This eliminates the need for custom mobile applications and ensures secure, browser-based communication. Network connectivity is provided through Wi-Fi, enabling flexible deployment within hospital infrastructure.

PROTOTYPE IMAGE

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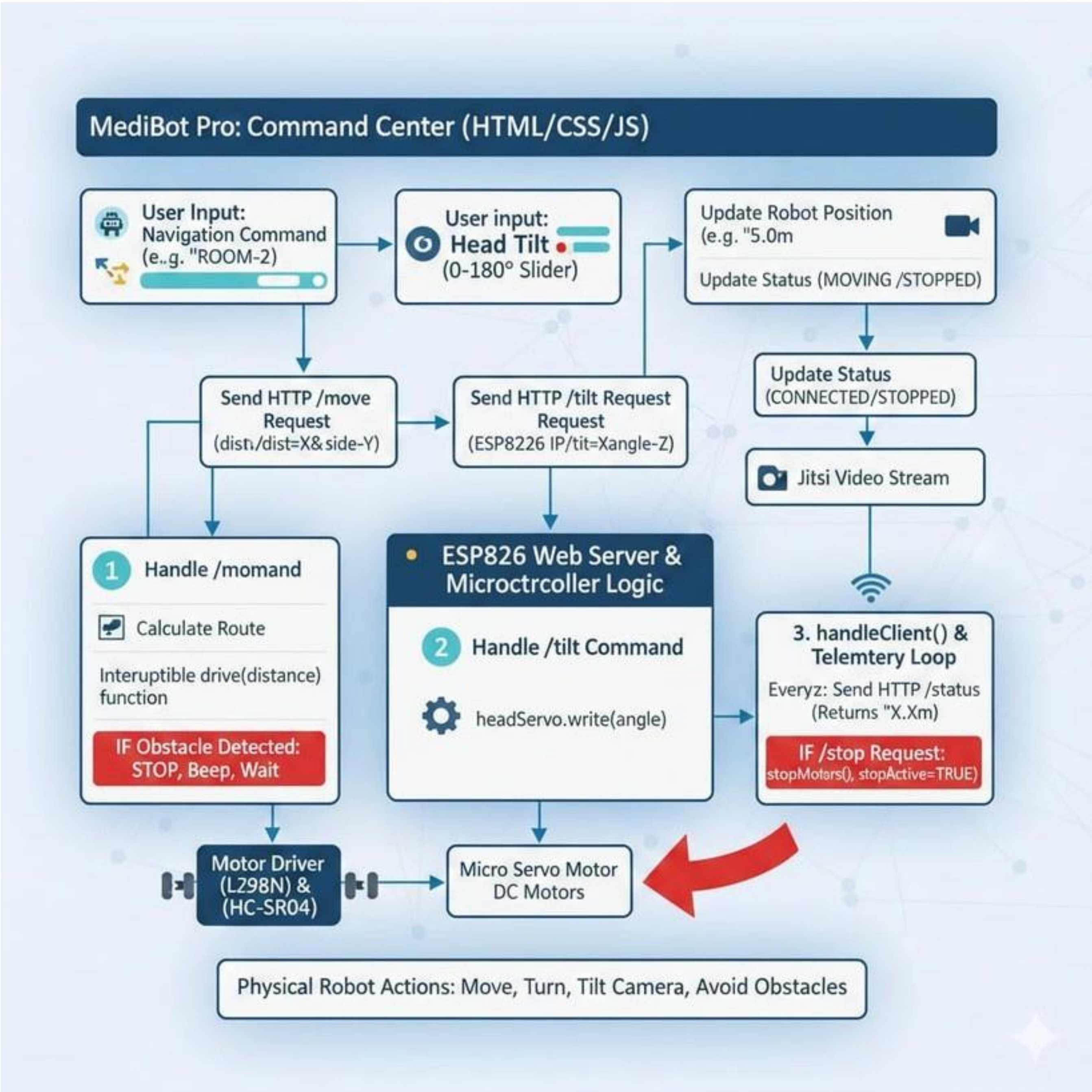
OPERATIONAL WORKFLOW :

Upon powering the system, the ESP8266 initializes the communication services and dashboard automatically. Doctors access the web interface to establish a live video session with the patient. The patient interacts through the display, camera, and audio peripherals without handling any electronic device. This methodology ensures ease of use, reproducibility, and scalability while maintaining low system cost.



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RESULTS AND DISCUSSION :

The performance of the proposed Smart Hospital Patient Monitoring Robot was evaluated based on its command execution accuracy, communication reliability, safety behavior, and overall usability. The results discussed in this section are derived from functional testing of the system workflow shown in Fig. X, which illustrates the complete command, control, and feedback loop of the robot.

COMMAND EXECUTION AND CONTROL RESULTS :

During testing, navigation commands entered through the web-based Command Center (HTML/CSS/JS) were successfully transmitted as HTTP /move requests to the ESP8266 controller. The robot responded correctly to forward, turn, and stop commands through the L298N motor driver, as depicted in the workflow. Camera head tilt commands issued via the 0–180° slider were accurately executed using the micro servo motor, providing smooth and precise camera orientation control.

Table X summarizes the observed command response behavior. In all test cases, command execution occurred within an acceptable response time under stable Wi-Fi conditions, meeting the expected system performance for indoor hospital environments.

OBSTACLE DETECTION AND SAFETY PERFORMANCE :

The HC-SR04 ultrasonic sensor effectively detected obstacles within the predefined safety range. When an obstacle was encountered, the robot immediately stopped, triggered an alert (beep), and waited for further instructions. This behavior confirms the reliability of the interruptible drive mechanism shown in the workflow. The absence of autonomous navigation reduced system complexity while improving operational safety, which aligns with the intended design objectives.

TELEMETRY AND STATUS FEEDBACK :

The telemetry loop continuously updated the robot's movement status and distance traveled through periodic HTTP /status responses. These updates were reflected accurately on the Command Center interface, allowing the user to monitor robot state in real time. Fig. Y illustrates the real-time status feedback mechanism during motion and stop conditions.

VIDEO COMMUNICATION RESULTS AND COMPARISON :

The integration of Jitsi Meet video streaming enabled stable real-time audio and video communication throughout robot operation. Compared to sensor-only patient monitoring systems reported in prior work, the proposed system offers enhanced interaction by combining mobility, live video, and web-based control. While commercial telepresence robots provide advanced autonomy, the presented solution achieves the core telepresence functionality at significantly lower cost and complexity.

DISCUSSION :

This project presented the design and implementation of a Smart Hospital Patient Monitoring Robot aimed at enabling remote doctor–patient interaction through a web-based control system. The developed architecture successfully integrates command input, ESP8266-based control logic, motor actuation, obstacle detection, telemetry feedback, and real-time video communication. Experimental evaluation demonstrated reliable command execution, stable audio–video streaming, and safe operation in indoor environments, fulfilling the primary objectives of the system. The proposed solution is suitable for applications in hospital wards, isolation units, and elderly care facilities where remote interaction is essential. However, the system is limited by its dependence on network connectivity and lack of autonomous navigation and medical sensors. Future work may focus on integrating health monitoring sensors, autonomous mobility, enhanced security, and scalability for large-scale hospital deployment.

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