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Interactive Humanoid Robot For Human Assistance

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Abstract: This project presents the design and development of an interactive humanoid robot for human assistance. The robot is built to imitate basic human movements and behaviors using servo motors, sensors, and a microcontroller-based control system. It is capable of performing tasks such as greeting visitors, responding to voice commands, and providing information through speech and display features. The system integrates mechanical design, embedded hardware, and intelligent software to achieve smooth motion and natural human–robot interaction. A Raspberry Pi is used as the main controller for processing inputs from sensors and controlling the robot's actions. The objective of this project is to create a low-cost, efficient, and functional prototype that can be used in educational institutions, service environments, and industrial assistance applications. The results demonstrate stable performance, effective communication, and reliable task execution, proving the feasibility of humanoid robots for real-world support and automation.

I. INTRODUCTION

A humanoid robot is a machine designed to resemble and imitate human body movements and behaviors using advanced mechanical, electronic, and software systems. With the rapid growth of automation and artificial intelligence, humanoid robots are increasingly used in environments where human assistance is required, such as educational institutions, service centers, healthcare, and industries. This project focuses on the development of an interactive humanoid robot capable of assisting humans through voice interaction, gesture-based movements, and simple task execution. The robot is built using a Raspberry Pi as the main controller along with servo motors, sensors, and display modules to achieve natural and smooth operation. By integrating hardware and software components, the system demonstrates how intelligent machines can support repetitive, hazardous, or time-consuming tasks. The project also aims to provide practical knowledge of embedded systems, robotics, and human–machine interaction while showcasing the real-world potential of humanoid robots in assistive applications.

II. Literature Survey

The literature survey highlights existing research and developments in humanoid robots that focus on human assistance, mobility, and natural interaction. Previous studies demonstrate the use of sensors, actuators, and AI to improve task execution and communication. These works provide a strong foundation for designing low-cost, efficient, and reliable interactive humanoid robots.

In [1], This study presents an AI-driven humanoid robot that performs both reception and advertising tasks in public spaces. The robot greets visitors, provides information, and displays digital ads using an integrated screen. It uses voice interaction and facial recognition to manage multitasking efficiently and naturally. The work highlights reduced human workload and improved user engagement compared to traditional systems.

In [2], This study focuses on real-time obstacle detection in mobile humanoid robots using ultrasonic sensors. The system measures distances continuously to detect and avoid collisions in dynamic environments. Intelligent control algorithms enable smooth slowing, stopping, and direction changes for safe navigation. The work improves robot mobility and human safety, making robots more reliable for public spaces.

In [3], This study developed an interactive robot assistant to guide visitors in educational institutions. The robot answered location-based queries and provided directions with 85% accuracy. It used mapping technology, basic AI, and voice interaction for real-time assistance. The system improved campus experience by reducing confusion and staff work load.

In [4], This study developed a Raspberry Pi–based voice-controlled humanoid robot with offline speech processing. The robot could perform basic movements and gestures in response to voice commands. It worked without internet, improving reliability and security in real-world environments. The research showed that low-cost hardware can enable natural and practical human–robot interaction.

III. SYSTEM REQUIREMENTS

- **Raspberry Pi 4**

The Raspberry Pi 4 Model is equipped with a powerful 64-bit quad-core processor running at 1.4 GHz, providing improved performance for embedded applications. It supports dual-band 2.4 GHz and 5 GHz wireless LAN along with Bluetooth 4.2/BLE for reliable wireless connectivity. The board has modular compliance certification, reducing the time and cost required for wireless testing in product development. It maintains the same mechanical footprint as the Raspberry Pi 4, ensuring easy hardware compatibility. The model also offers clearly defined GPIO pin layouts for efficient hardware interfacing and system integration.

Figure 3.1: Raspberry Pi 4

- **7 – INCH TouchScreen**

A 7-inch touch display is widely used with Raspberry Pi for graphical interfaces and control panels. It typically supports a resolution of 800 × 480 pixels or higher for clear and sharp visuals. The screen features capacitive multi-touch, enabling smooth gestures like tapping and scrolling. It connects easily via USB, GPIO, DSI, or HDMI for both display and touch functionality. Additional features include good brightness, wide viewing angles, and easy mounting options.

Figure 3.2: 7 – INCH TouchScreen

- **USB / 3.5 mm Speaker**

  A powered speaker or compact 3–5W amplifier speaker is used to provide clear audio output from the Raspberry Pi. It connects through a 3.5 mm audio jack or a USB audio adapter for better sound quality. The speaker enables text-to-speech responses, alerts, and interactive voice prompts. It allows the humanoid robot to communicate verbally and interact naturally with users. The lightweight and compact design makes it easy to install inside robotic enclosures.

Figure 3.3: USB / 3.5mm Speaker

- **Micro SD Card (16-32 GB)**

  A MicroSD card serves as the main storage for the Raspberry Pi, holding the operating system, software, and project files. It enables the system to boot and supports smooth functioning during tasks like running GUIs and managing applications. For Raspberry Pi 3 and 4, using a 16GB–32GB card with good read/write speed ensures stable and efficient performance. It helps achieve faster boot times, quick loading of programs, and reliable handling of robotics functions. Overall, a quality MicroSD card is essential for maintaining the Raspberry Pi's speed, stability, and responsiveness.

Figure 3.4: Micro SD Card

- **Power Supply**

  A high-discharge 11.1V Li-Po/Li-ion battery pack powers the motors, controllers, and actuators of a humanoid robot with stable and reliable voltage. Its 2500mAh capacity offers moderate runtime based on the robot's load and activity level. The battery can deliver high current bursts needed for actions like joint movement and walking. Its lightweight and compact design makes it ideal for mobile robotic systems. Proper charging, balancing, and safe handling are essential to ensure long battery life and safe operation.

Figure 3.5: Li – Po Battery (Power Supply)

- **Robot Body Case**

A lightweight yet durable 3D-printed body forms the main chassis of the humanoid robot, securely housing all sensors, servos, and electronic components. Materials like PLA, PETG, or ABS provide strength, flexibility, and ease of fabrication. With a total weight of about 3 kg, the structure supports motors and actuators while allowing smooth and efficient movement. Its balanced design helps the robot maintain stability during walking, turning, and performing limb or head motions. The modular casing enhances appearance, protects electronics, and allows easy repairs, upgrades, and feature integration.

Figure 3.6: Robot Body / Case

IV. ARCHITECTURE

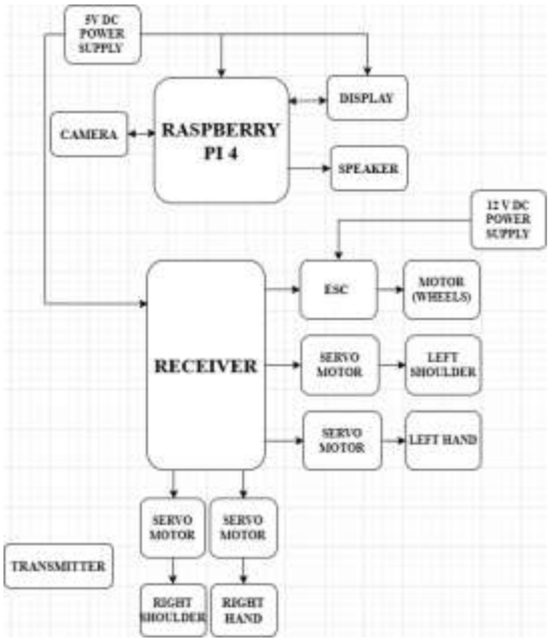

Figure 4.1: Architecture of Interactive Humanoid Robot for Human Assistance

Figure 4.1 shows the architecture of Interactive Humanoid Robot for Human Assistance. The block diagram represents the working architecture of an interactive humanoid robot, illustrating how various hardware components communicate to perform movement, interaction, and control functions. The Raspberry Pi 4 acts as the central processing unit, powered by a 5V DC supply. It manages high-level operations such as video processing through the camera, audio output through the speaker, and visual information display. The Raspberry Pi also communicates with the receiver module, which handles wireless signals transmitted from the remote controller or transmitter. The receiver distributes these control signals to multiple actuators. Servo motors connected to the right shoulder, right hand, left shoulder, and left hand enable precise limb movements. These servos receive position commands for performing gestures or arm actions. The receiver also interfaces with the Electronic Speed Controller (ESC), which regulates the speed and direction of the wheel motors powered by a 12V DC supply, enabling mobility. The ESC ensures smooth and controlled wheel motion, allowing the robot to move forward, backward, or turn. The integrated camera provides real-time feedback to the Raspberry Pi, supporting tasks like monitoring and navigation. Altogether, the diagram shows a coordinated system where sensors, actuators, and controllers work together to achieve humanoid motion and interactive behavior.

V. FLOWCHART

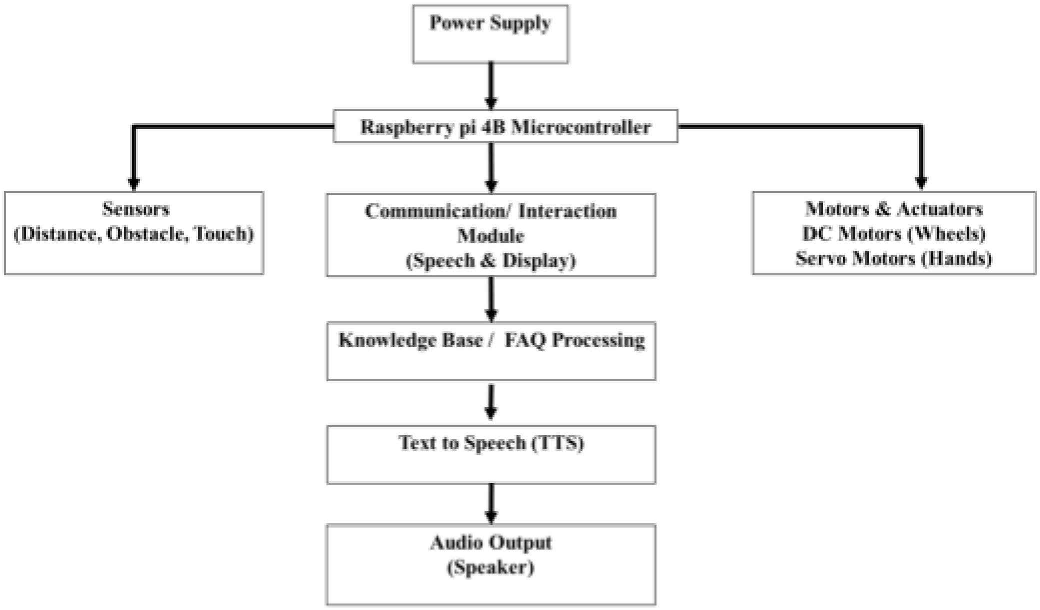

Figure 5.1: Flowchart of Interactive Humanoid Robot for Human Assistance

VI. RESULTS AND DISCUSSION

Figure 6.1: Front View of Project

Figure 6.2: Rear View of Project

Figure 6.3: Circuit Connectionof Project

Figure 6.3: LCD Display of Project

The Interactive Humanoid Robot performes well during the testing and finished the necessary tasks. The robot showed that it could understand basic voice commands and responds with understandable voice. The sendsor's precise obstacle detection allowed the robot to move safely without running into anything. If the camera could recognize faces and people, the robot might become more interactive . the smooth operation of the motors allowed the robot to move it's body , head , and hands without problem . Because every piece of hardware and software worked properly , robot was able to greet people , answer simple questions , and travel to the short distance by manual control. By considering all the things, the robot performed admirably and showed its potential.

VII. CONCLUSION

This project successfully demonstrates the design and development of an interactive humanoid robot capable of performing basic human-like actions through the effective integration of mechanical, electrical, and software systems. The prototype was developed using a Raspberry Pi as the central controller, along with servo motors, sensors, a camera module, display unit, and audio output systems to enable smooth movement, real-time interaction, and responsive behavior. The robot was able to perform essential tasks such as arm and hand movements, environmental sensing, voice responses, and visual display, proving the reliability and efficiency of the overall system. The outcomes of this project highlight the practical feasibility of developing low- cost humanoid robots for real-world applications such as education, assistance services, and customer interaction roles. This work also reflects the importance of interdisciplinary learning, as it combines concepts from electronics, programming, mechanical design, and control systems. Despite certain limitations such as complexity in design, maintenance challenges, and limited emotional intelligence, the project serves as a strong foundation for future advancements in humanoid robotics. With further development, the system can be enhanced by integrating advanced artificial intelligence, better vision algorithms, improved mobility mechanisms, and more natural human–robot interaction features. Overall, the project proves that humanoid robots have significant potential to support human activities, reduce manual effort, and improve efficiency in many fields, offering a promising direction for future research and innovation

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