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Development of Humanoid Robot with IoT System

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ABSTRACT: This report explores the design, development, and applications of humanoid robots—machines engineered to resemble the human body in form and function. The goal of this report is to provide a comprehensive overview of how humanoid robots are created, the technologies that enable them, and the roles they are increasingly playing across various industries. Humanoid robots typically feature a human-like structure with articulated limbs, sensors, and actuators, allowing them to perform tasks that require mobility, dexterity, and interaction with humans. The report examines the core components of humanoid robots, including mechanical design, control systems, artificial intelligence, and sensory integration. Particular attention is given to how these systems work together to facilitate functions such as walking, object manipulation, facial recognition, and voice communication. Additionally, the report highlights the real-world applications of humanoid robots in fields such as healthcare (e.g., elderly care assistants), education (e.g., teaching aids), customer service (e.g., reception and guidance), and disaster response.

KEYWORDS: Speech Recognition, Servo Motors, Facial Recognition

I. INTRODUCTION

Humanoid robots are advanced robotic systems designed to imitate the human form and behavior, enabling more natural interaction with people. A specialized branch of these robots is the humanoid welcoming robot, created specifically to serve as a host or greeter in environments such as offices, hotels, shopping malls, hospitals, exhibitions, and public service centers. These robots are equipped with sensors, cameras, speech recognition, and interactive displays to perform tasks such as greeting visitors, providing directions or information, and even engaging in simple conversations.

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The robot will use various technologies such as speech-to-text engines, facial recognition software, touch-screen interfaces, and motion sensors. The integration of artificial intelligence (AI) will enable adaptive responses and improved communication over time.

II. LITERATURE SURVEY

Arkin (1998) presents a foundational framework for behaviour-based robotics, emphasizing decentralized control and real-time interaction with the environment. The work shifts focus from traditional deliberative planning to reactive and emergent behaviours. This approach has significantly influenced the design of autonomous agents in dynamic and unpredictable settings.[1]

Asada et al. (2001) introduce cognitive developmental robotics as a novel paradigm inspired by human infant learning. The study emphasizes the integration of perception, action, and social interaction to enable robots to acquire cognitive functions autonomously. This work laid the groundwork for humanoid robots that learn and adapt through developmental processes.[2]

Bekey (2005) provides a comprehensive overview of autonomous robots, drawing inspiration from biological systems to guide design and control strategies. The book bridges theory and practical implementation, highlighting challenges in autonomy, sensing, and learning. It serves as a key resource for understanding the interdisciplinary nature of autonomous robot development.[3]

Pfeifer and Bongard (2006) propose that intelligence is deeply rooted in the physical embodiment of an agent, emphasizing the role of morphology in shaping cognition. Their work introduces the concept of "embodied intelligence," where body structure, environment, and control are tightly interlinked.[8]

III. METHODOLOGY

Software engineering, electronics, and mechanical design are all integrated into the process of creating a humanoid robot. In order to replicate human anatomy, the robot is first designed using CAD software. It is then manufactured using CNC machining. To allow for fluid, human-like movements, servo motors and actuators are positioned at strategic joints. Sensors and cameras allow the robot to interact with its surroundings, while microcontrollers like the Arduino or Raspberry Pi are used to control its operations. Python is used in software development, along with libraries such as OpenCV for real-time face detection and AI models for decision-making and gesture recognition. Inverse kinematics is used to control motion in order to mimic human movement. The system is continuously tested and improved to increase its responsiveness, accuracy, and capacity for human interaction.

IV. APPLICATIONS

Social Interaction: Human-robot social interaction plays an essential role in extending the use of robots in daily life. Robots will be able to perform a lot of additional tasks if they possess the gift of social interaction. These robots can be used to help the aged, work with children having autism and patients finding physically or mentally difficult to perform tasks. Rather than mechanically performing tasks, if robots can respond intelligently, use proper body language, smile and react to a joke, accepting robots as part of our daily lives will also become quite easy.



Fig. 4.1 Robo

V. BLOCK DIAGRAM

Fig. 5.1

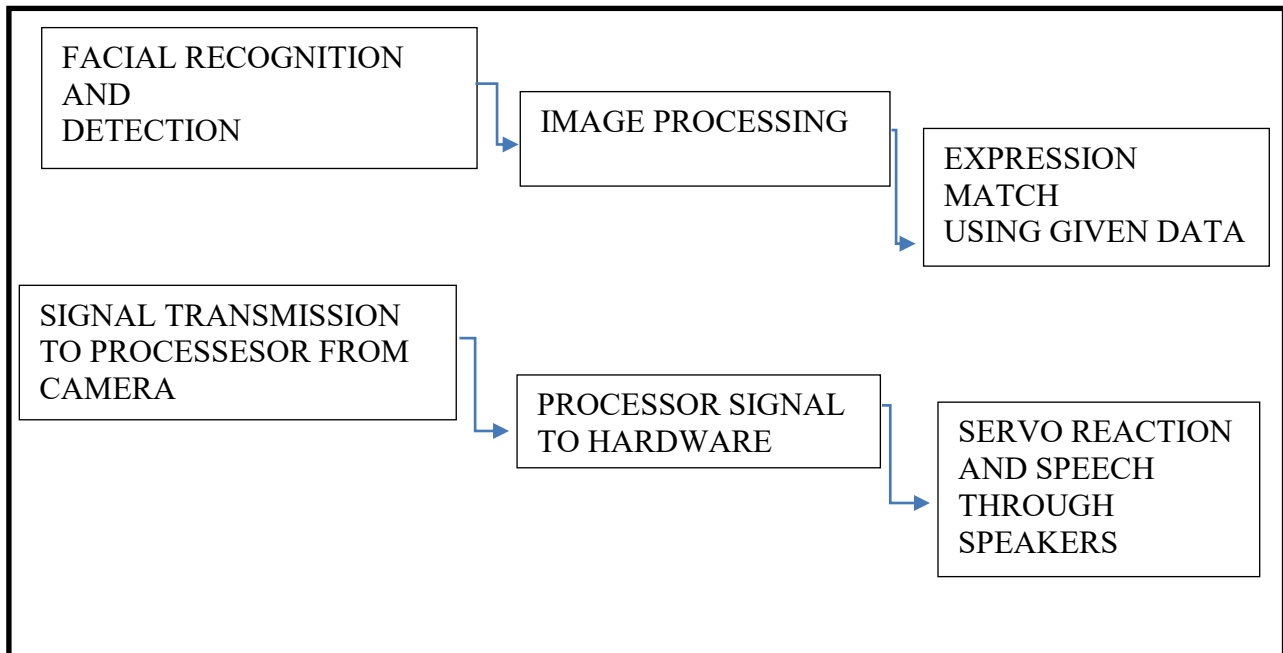


Fig. 5.1 Robo

VI. COMPONENTS

1. RASPBERRY PI 4

This board supports full operating systems like **Raspberry Pi OS (Linux-based)** and can run Python, C/C++, and other programming languages. It is especially useful in robotics projects as it can handle real-time image processing, AI models, and communication with sensors or microcontrollers like Arduino. In welcoming robot applications, Raspberry Pi 4 can manage tasks such as voice recognition, camera input, and interaction logic with ease.

2. ARDUINO UNO

The Arduino Uno is a popular open-source microcontroller board based on the ATmega328P microcontroller. Known for its simplicity, affordability, and ease of use, it is widely used in educational, hobbyist, and prototyping projects, especially in robotics and automation.

The board features 14 digital I/O pins, 6 analog inputs, a 16 MHz quartz crystal, USB connection, power jack, and ICSP header. It can be powered via USB or an external power supply. The Arduino Uno is programmed using the Arduino IDE, which supports a simple, user-friendly programming language based on C/C++.

3. LED MATRIX

An LED matrix is a grid of LEDs that can be individually controlled to display various patterns, symbols, or animations. For a humanoid robot, an LED matrix is an ideal solution for creating dynamic eye expressions. The matrix can be programmed to simulate emotions such as happiness, surprise, sadness, and anger, as well as basic eye movements like blinking, looking around, or following a target.

4. SERVO MOTOR 20KG X2

Servo motors are essential components for controlling precise movements in robotic systems. They consist of a DC motor, gearbox, and control circuit, making them capable of rotating to specific positions based on input signals. In the case of your humanoid robot, 30kg servo motors for the arms and 10kg servo motors for the neck provide the necessary torque to move these body parts.

5. 22AWG WIRE

22 AWG (American Wire Gauge) wire is a common wire size used in electronics and robotics projects for connecting low-power components such as sensors, LEDs, servo motors, and microcontrollers. The number "22" refers to the thickness of the wire—the higher the AWG number, the thinner the wire. A 22 AWG wire has a diameter of approximately 0.64 mm (0.025 inches).

6. BUCK CONVERTER

A buck converter, also known as a step-down voltage regulator, is an essential power management device used in electronics and robotics. Its main purpose is to reduce a higher input voltage to a lower, stable output voltage with high efficiency. This is crucial in robotic systems where different components require different voltage levels to operate safely.

7. SPEAKER

A speaker is an output audio device that converts electrical signals into sound. In a humanoid welcoming robot, a speaker allows the robot to talk, play sounds, or respond with audio feedback, making it more interactive and engaging for users. When paired with a microphone and a voice recognition system, a speaker completes the audio loop for natural human-robot communication.

8. MIC

A microphone is an audio sensor that captures sound waves and converts them into electrical signals. In humanoid robot applications, a microphone is crucial for enabling voice recognition, sound detection, and interactive communication with users. This allows the robot to respond to voice commands, recognize speech, or detect when someone is nearby by sound.

9. SHEET METAL FRAME

A sheet metal frame provides a lightweight yet strong structural foundation for humanoid robots. Its modularity enables easy customization and integration of actuators, sensors, and control units. The design supports precise joint alignment and durable mechanical connections. Sheet metal fabrication also allows for cost-effective prototyping and scalability. Overall, it ensures structural rigidity while maintaining mobility and human-like proportions.

VII. CONCLUSION

The development of a humanoid robot represents a significant step toward bridging the gap between human capabilities and robotic automation. This project has demonstrated the integration of multiple engineering disciplines, including mechanical design, control systems, sensor integration, and artificial intelligence, to build a robot capable of human-like motion and interaction. Through careful planning, iterative prototyping, and rigorous testing, the humanoid robot was able to achieve stable bipedal locomotion and perform basic tasks such as object recognition and simple gestures.

While the current prototype serves as a foundational model, there remain challenges in areas such as dynamic balance, natural language understanding, and adaptive behavior. Future work may involve the implementation of advanced machine learning algorithms, improved actuation mechanisms, and more intuitive human-robot interfaces to enhance the robot's autonomy and social capabilities.

In conclusion, this project not only showcases the feasibility of building humanoid robots but also highlights their potential applications in fields such as healthcare, education, service industries, and human-robot collaboration.

Continued research and development will be crucial in realizing more intelligent, responsive, and human-friendly robotic systems.

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