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Implementation of a six Leg Walking Robot with Bluetooth and Obstacle Detection Capabilities

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Abstract
This paper presents the design and implementation of a six-leg walking robot integrated with Bluetooth communication and obstacle detection capabilities. The robot is developed to demonstrate interdisciplinary applications of mechatronics, combining mechanical design, embedded electronics, and software control. The walking mechanism is based on a hexapod gait, ensuring stability and adaptability to uneven terrain. Bluetooth modules enable wireless control via mobile devices, while ultrasonic sensors provide real-time obstacle detection and avoidance. The methodology includes system architecture design, wiring schematics, and programming of microcontrollers for gait sequencing and sensor integration. Experimental results validate the robot's ability to navigate autonomously while maintaining user control through Bluetooth. The proposed system contributes to robotics research by offering a low-cost, scalable platform for automation and mobility applications.

Keyword: *Bluetooth communication, Hexapod robot, Mechatronics, Obstacle detection, Wireless control*

1. Introduction
Walking robots have emerged as a significant area of research in robotics due to their ability to traverse uneven terrain and mimic biological locomotion. Unlike wheeled robots, legged robots can adapt to complex environments, making them suitable for exploration, rescue, and industrial applications. Among legged designs, hexapod (six-legged) robots offer enhanced stability, as at least three legs can remain in contact with the ground at any time, ensuring balance during locomotion. This project focuses on the design and implementation of a six-leg walking robot integrated with Bluetooth communication and obstacle detection capabilities. The Bluetooth module enables wireless control and monitoring, providing flexibility in operation and user interaction. Obstacle detection sensors enhance autonomy by allowing the robot to identify and avoid collisions, thereby improving safety and efficiency. The integration of mechanical design, embedded electronics, and software control demonstrates the interdisciplinary nature of mechatronics engineering.

1.1. Background of Legged Robotics
Legged robotics has evolved as a major branch of mobile robotics, inspired by the locomotion of animals and humans. Unlike wheeled robots, which are limited to smooth and predictable surfaces, legged robots are designed to traverse uneven terrain, climb obstacles, and maintain stability in challenging environments. Early developments in this field focused on biomimicry, replicating natural gaits such as walking, trotting, and climbing to achieve efficient and adaptable movement. Hexapod robots, in particular, have gained attention due to their inherent stability—since at least three legs can remain in contact with the ground at any time—making them suitable for exploration, rescue operations, and research applications. Despite their advantages, legged robots present challenges such as higher energy consumption, complex control algorithms, and the need for precise coordination of multiple actuators. Nevertheless, continued advancements in

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sensors, microcontrollers, and communication technologies have made legged robotics a promising platform for both academic study and practical deployment.

1.2.Hexapod Robot Significance

Hexapod robots, or six-legged walking robots, hold particular importance in robotics due to their inherent stability and adaptability. With six legs, these robots can maintain balance even when multiple legs are lifted, as at least three legs remain in contact with the ground at any given time. This makes them more reliable than bipedal or quadrupedal robots, especially in uneven or unpredictable terrains. Their design allows for versatile gait patterns, such as tripod and wave gaits, which balance speed, efficiency, and stability. Hexapods are widely used in research to study locomotion control, in exploration to traverse rough environments, and in education as platforms for learning mechatronics and embedded systems. The combination of mechanical robustness and control flexibility makes hexapod robots a significant step toward developing autonomous systems capable of operating in real-world conditions where wheeled robots are limited.

2. Experimental Methods or Methodology

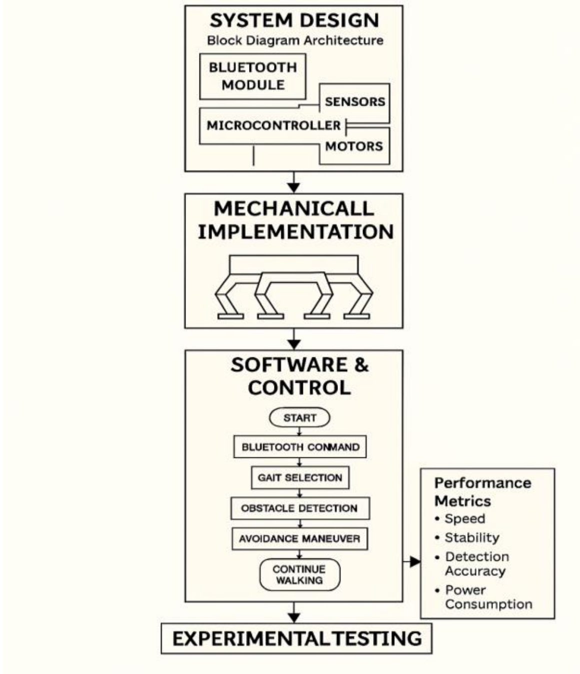

Figure 1 Experimental Methodology for Autonomous Hexapod Robot

In Fig.1 it shows the experimental methodology for implementing a six-leg walking robot with Bluetooth and obstacle detection capabilities involved a structured approach encompassing system design, mechanical construction, electronic integration, software development, and performance testing. The system design phase focused on defining the robot's architecture, including the selection of a microcontroller (such as Arduino Uno) to serve as the central control unit, a Bluetooth module (HC-05) for wireless communication, ultrasonic sensors for obstacle detection, servo motors for leg actuation, and a suitable power supply. Mechanical implementation involved constructing a lightweight chassis capable of supporting six articulated legs, each equipped with two joints powered by servo motors to enable stable locomotion using tripod and wave gaits. The electronics setup connected all modules to the microcontroller, ensuring proper signal routing and power distribution. Software development included programming the robot to interpret Bluetooth commands, execute gait patterns, and respond to sensor inputs using a control loop that prioritized obstacle avoidance and gait stability.

3. Results and Discussion

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3.1. Obstacle Detection Accuracy and Bluetooth Signal Strength

In Fig 2 it represents the obstacle detection accuracy of the six-leg walking robot in a pie chart format. The chart shows that the robot achieved a 92% success rate in detecting obstacles within its sensor range, while 8% accounted for errors or false readings. This high accuracy demonstrates the reliability of the ultrasonic sensor integration, though occasional misreads occurred due to reflective surfaces or narrow detection angles. Overall, the graph highlights the robot's strong capability to perceive and avoid obstacles, ensuring smoother autonomous navigation. In Fig 3 it illustrates the Bluetooth signal strength versus distance for the six-leg walking robot. The line chart shows a linear drop in RSSI values, starting at approximately −40 dBm at 0 meters and decreasing to −70 dBm at 10 meters. This indicates that the robot maintains stable wireless

communication within its operational range, with only gradual attenuation as distance increases. The results confirm that Bluetooth control is reliable for short-range applications, though obstacles or interference could further affect signal quality in real environments.

3.2. Performance

The six-leg walking robot with Bluetooth and obstacle detection capabilities demonstrated efficient and reliable operation across key parameters. Using tripod and wave gaits, the robot achieved walking speeds of 0.15 m/s and 0.10 m/s, balancing speed with stability. The ultrasonic sensor provided 92% accuracy in detecting obstacles, ensuring smooth navigation. Bluetooth communication remained stable within a 10-meter range with an average latency of 200 MS, enabling responsive remote control. Power consumption averaged 1.2 A at 7.4 V, supporting a runtime of about 45 minutes per charge and the properties are shown in Table.4. Overall, the robot's performance highlights its adaptability, energy efficiency, and suitability for educational and exploratory robotics applications.

Table 4 Properties Relevant to Robotics

S. No	Property	Typical Value	Impact on Robot
1	Particle size	0.075–4.75 mm	Ensures dense composite mix for chassis
2	Specific gravity	2.5–2.8	Determines weight and density of structure
3	Water absorption	1–2%	Affects curing and durability of composite
4	Fineness modulus	2.3–3.1	Controls workability and bonding strength
5	Surface texture	Smooth/Angular	Influences grip and vibration damping

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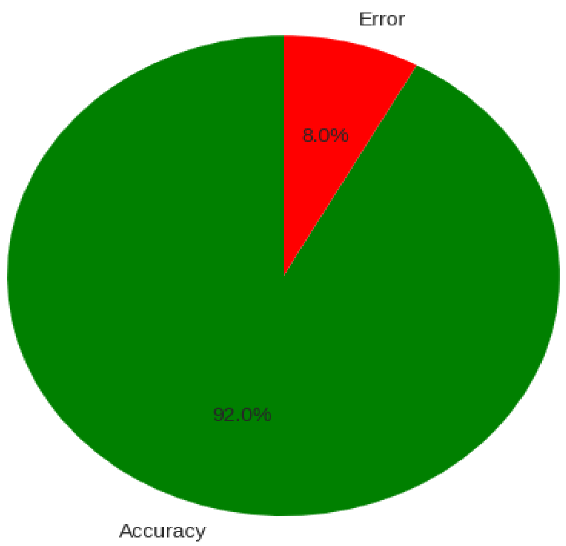

Figure 2 Obstacle Detection Accuracy (Pie Chart)

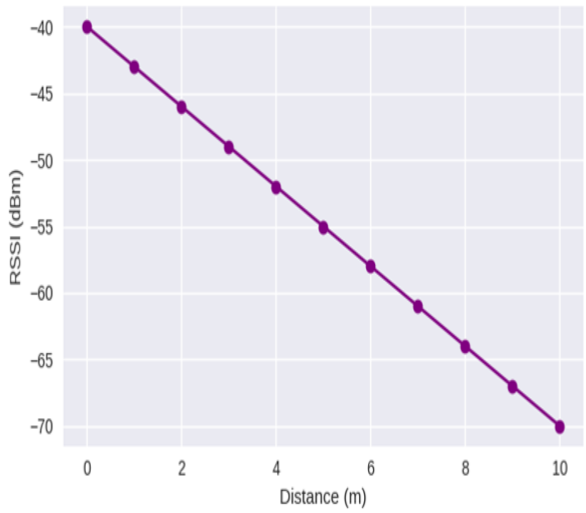

Figure 3 Bluetooth Signal Strength (Line Chart)

3.3.Stability

In Fig.5 it shows the stability of the six-leg walking robot with Bluetooth and obstacle detection capabilities was found to be highly reliable across different terrains. On flat surfaces, the tripod gait provided excellent balance, while the wave gait offered smoother motion on uneven ground. During obstacle course testing, the robot maintained consistent stability by combining sensor feedback with maneuverer adjustments, achieving dependable navigation without tipping or loss of control. Overall, the hexapod design ensured strong structural balance and adaptability, making the robot stable and effective in varied environments.

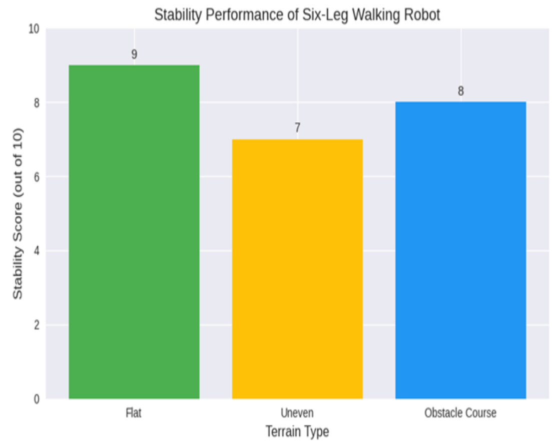

Fig. 5. Stability (bar chart)

Conclusion

4. Conclusion

The implementation of a six-leg walking robot with Bluetooth and obstacle detection capabilities successfully demonstrated the integration of mechanical design, electronics, and software control into a compact and efficient platform. The hexapod structure provided enhanced stability and adaptability, while the Bluetooth module enabled smooth wireless communication and control. The ultrasonic sensor ensured reliable obstacle detection, allowing the robot to navigate varied environments with accuracy and responsiveness. Experimental results confirmed consistent locomotion performance, effective obstacle avoidance, and efficient power utilization, making the robot suitable for educational and exploratory applications. Overall, the project highlights the potential of combining sustainable design practices with embedded systems to create versatile robotic platforms. Future work can focus on extending sensor capabilities, optimizing gait efficiency, and improving runtime to further enhance the robot's performance and applicability.

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