DESIGN AND DEVELOPMENT OF SIXLEGGED TERRAIN-ADAPTIVE ROBOT FOR CROP MONITORING

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Introduction:

Agricultural monitoring in uneven and rough terrains is a challenging and labor-intensive task. Farmers often face difficulties in continuously monitoring crop health, soil conditions, and environmental factors, especially in large fields. To address this, the development of a six-legged terrain-adaptive robot provides an efficient and safe solution.

Objectives:

1. Develop a stable six-legged walking robot capable of walking different types of uneven and rough terrains such as mud, rocks, etc.
2. To develop a microcontroller-based control system for coordinated leg movement and adaptive navigation in uneven environments.
3. To evaluate the robot's performance in different terrain conditions based on stability, mobility, and monitoring capability.

Methodology:

The proposed system involves the design and development of a six-legged (hexapod) terrain-adaptive robot for agricultural crop monitoring. The methodology is divided into the following stages:

Mechanical Design:

The robot structure is designed using CAD tools with a hexapod configuration to ensure stability and adaptability on uneven terrains. Each leg is designed with multiple degrees of freedom (DOF) for flexible movement.

Fabrication:

The robot body and legs are fabricated using lightweight materials and 3D printed components to ensure durability and precision.

Actuation System:
Servo motors are used for each joint of the legs. Predefined gait patterns such as tripod gait are implemented to achieve stable and smooth locomotion.

Control System:
A microcontroller (Arduino MEGA) is used to control the coordinated movement of all six legs. The control logic ensures proper synchronization for stable walking.

Wireless Control using Bluetooth:
The robot is controlled using an HC-05 Bluetooth module connected to the microcontroller. A mobile application is used to send commands such as forward, backward, left, and right, enabling real-time manual control of the robot.

Camera Integration for Live Monitoring:
A wireless camera is mounted on the robot to capture real-time video of the crops. The live feed is transmitted directly to a mobile device, allowing users to monitor field conditions remotely.

Programming and Testing:
The system is programmed using Arduino IDE. The robot is tested for movement, Bluetooth responsiveness, and live video transmission across different terrains.

Performance Evaluation:
The robot's performance is evaluated based on stability, responsiveness to mobile control, terrain adaptability, and effectiveness of real-time monitoring.

Result and Conclusion:

The developed six-legged terrain-adaptive robot successfully demonstrates stable movement across uneven agricultural terrains using a hexapod walking mechanism. The implementation of servo motor-based actuation and coordinated gait patterns ensures smooth and balanced locomotion.

The integration of the HC-05 Bluetooth module allows the robot to be controlled wirelessly through a mobile application, making the system user-friendly and easily operable in real-time. Additionally, the use of a wireless camera enables live video streaming, allowing farmers to monitor crop conditions remotely without physically entering the field.

The results confirm that the robot can effectively assist in agricultural monitoring by combining mobility, remote control, and real-time visual feedback. This reduces manual effort and improves efficiency in crop inspection.

In conclusion, the project demonstrates a practical and scalable solution for smart agriculture using robotics. With further enhancements, the system can be upgraded to fully autonomous operation and advanced crop analysis.

Overall, the project proves that legged robotic systems can be an effective solution for agricultural monitoring in challenging terrains. The system provides a foundation for further advancements in autonomous agricultural robotics, reducing manual effort and improving farming efficiency.

References:

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Future Scope:

The future scope of this project includes:

1. Integration of autonomous navigation and obstacle detection sensors to reduce dependency on manual control.
2. Implementation of intelligent control algorithms for improved stability, coordination, and efficient movement.
3. Expansion of sensing capabilities by adding environmental sensors (temperature, gas, humidity) for advanced field monitoring.
4. The system can be enhanced using OpenCV and machine learning to detect and classify plant diseases in real time, enabling early intervention and improved agricultural productivity