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DESIGN AND DEVELOPMENT OF QUADRA LEGGED ROBOT FOR SMART MOBILITY AND OBSTACLE NAVIGATION

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Abstract - *This project presents the design and development of a quadra legged spider robot designed for smart mobility and obstacle navigation on rough surfaces. The robot uses a stable mechanical body structure and servo based joint for legs and a microcontroller to control the locomotion. Ultrasonic sensor used in this project enables obstacle detection and navigate back to its position while moving and also an Bluetooth camera fixed for live tracking and controlling. The system for this project was built through different stages like designing, prototyping, programming, and testing. Results showed that the robot can walk smoothly on irregular paths and adjust its moments when obstacle appears. This work demonstrates the usefulness of four legged robots in environments where wheeled robots cannot reach in some environments and this provides a foundation for future improvements.*

Key Words: **Quadra legged robot, Spider robot, Servo based joints, Ultrasonic sensor, Obstacle detection, Locomotion, Rough surface navigation.**

1. INTRODUCTION

This project involves the design and development of a quadra legged spider robot that can walk smoothly and avoid obstacles on uneven surfaces. Unlike wheeled robots this legged robots this legged robot can move over rough ground, climb small obstacles and reach places where wheels cannot work. The robot is also integrated with an small Bluetooth camera module that helps to record and share the live streaming to the operator. The robot has four legs powered by servo motors and microcontroller that helps in controlling the moments. Sensors are used to detect obstacles allowing the robot to change its path and prevent collisions.

The project includes designing the leg structure building the electronic system and programming for different walking patterns and mainly focused on programming the leg moment part where that must like a real spider. The robot can perform basic actions such as walking forward, turning left and right and then stopping while the commands are received and when the auto mode is turned ON it automatically starts avoiding the obstacles and in the overall functioning the camera will be kept turned ON for live streaming and recording the video.

This work shows how a quadra legged robots can be useful for rescue missions, surveillance, rough terrain exploration and educational purposes which helps the students to learn and understand how the basic leg moments of a robot work. Overall, the project highlights how mechanical design, electronics, and programming come together to create a stable and flexible spider like robot.

2. LITERATURE REVIEW

Previous studies on quadra legged robots show that legged systems can move better on uneven surfaces compared to wheeled robots. Many researchers have used motors, basic gait patterns and sensors to improve walking stability and obstacle detection. However, most of these designs are either expansive or complex for beginners to understand and observed the main thing in which there is no camera module integrated. To address this a simple lost cost models have been developed for education but they often lack smooth moment or smart sensing. This project Builds on these ideas by creating an affordable Quadra legged robot with servo based legs and ultrasonic sensing to achieve stable walking and basic obstacle avoidance.

3. SYSTEM DESIGN

The system design of the quadra legged robot integrates both mechanical and electronic components to achieve efficient movement and control. The mechanical design focuses on lightweight, stable structure with a 3 degree of freedom legs for smooth walking on uneven surfaces. The electronic design includes servo motors, sensors and a control module that enables to control the moment and functions of the robot. Together these designs ensure the robot functions with maintaining good balance, flexibility in various environments.

3.1 Mechanical Design

The robot is developed by using a lightweight body structure for good stability and mobility. Its four legs with each lags of

3 degree of freedom which offers a goof balance of strength and reduced weight. Each leg has simple, well designed joints that enables both forward and backward moment. Fig-3.1 shows the 3D-printed body and leg parts of the robot. The overall structure is designed and developed to be flexible, durable while walking on uneven surfaces or slightly rough surfaces making it suitable for both indoor and outdoor exploration.

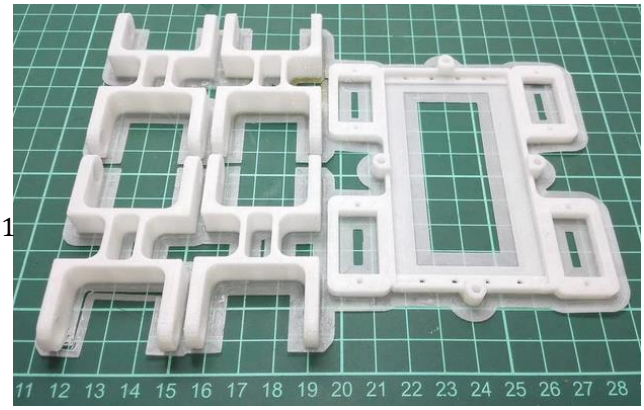

Fig -1: 3D-printed body and leg parts of the robot.

3.2 Electronics Design

The electronic system of the robot is built using a Arduino uno which acts as the central brain responsible for controlling all the leg moments and processing sensor input. Each leg is equipped with servo motors that follow a programmed gait pattern allowing the robot to walk smoothly and maintain a good balance. To enable the obstacle detection an ultrasonic sensor is mounted at the front of the robot that continuously measures the distance to nearby objects and sends the signals to the controller for avoidance actions. Fig-3.2 shows the entire system is powered by a rechargeable battery that helps to recharge multiple times.

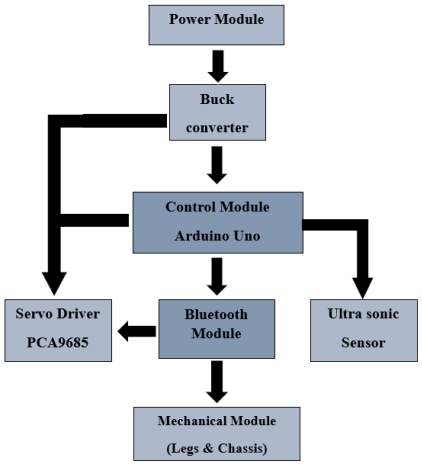

Fig-2: Power and Control Flow

4. METHODOLOGY

The methodology involves the systematic design of the robot starting from planning the structure, assembling the mechanical parts and then integrating all electronic modules required for moment, sensing, communication, and power management. Each hardware component has a specific role in which that helps the robot for stable locomotion, wireless control and efficient operation.

4.1 Arduino uno

Fig -3: Arduino Uno

The Arduino uno acts as the main controller for the robot that helps in processing the sensor data that receives from that Bluetooth module from that operators and then using that signals in controls the moment of the robot through programmed instructions. Fig -3 shows it has many analog pins and digital pins mounted to it in which they helps to connect the external components.

4.2 PCA9685 Servo driver

Fig -4: PCA9685

The PCA9685 servo driver board is used to control multiple servos at single operation. Fig -4 shows it is like a expansion board that allows to control multiple servos by passing the power and the ground signal constantly by just fluctuating the signal as per the program. It helps in generating smooth and accurate leg moments for the robot.

4.3 HC-05 Bluetooth module

Fig -5: HC-05

It enables wireless communication between the robot and a mobile controlling device. It allows the user to send movement commands. Fig -5 shows this module has two pins in which one pin helps to receive the command from the operator app and other pin to transfer the signal to the uno in the programmed method.

4.4 Ultrasonic sensor

Fig -6: Ultrasonic sensor

It detects obstacles in front of the robot that helps the robot to stop or change directions to avoid collisions. Fig -6 The ultrasonic sensor gets activated only when the command is received.

4.5 Bluetooth camera module

Fig -7: BT camera

This module installed in the robot provides live video allowing remote monitoring of the robots path and surroundings that helps the operator to control the robot without any collusions. Fig -7 shows the Bluetooth camera selected for this project because this time of cameras work without any delay in streaming the video continually.

4.6 SG-90 Servo motor

Fig -8 the SG-90 servo motor provides a precise rotational moment for each leg joint of the robot. It allows controlled motion for walking, turning. This motor is a plastic gear motor in which it consume less power to operate.

Fig -8: Servo motor

4.7 Power supply

Fig -9: Lithium battery

Fig -9 shows the lithium battery used in the robot which is a rechargeable battery that supplies power to entire system including the controller, servo motors and sensor. The tsp charger module is used to charge the batteries in which they are safe if connected in series and then charged with a specific voltage maintaining a certain charging time.

5. WORKING

The robot walks using a designed gait pattern where two legs move forward while the other two stay in the home position on the ground to support the body. This alternating moment gives the robot good stability and smooth forward motion in which the Arduino uno controls the timing of each step by sending the exact signals to servos as per the programming. The signal from the HC-05 is received from the controller app and then as per the signal received the Arduino sends the signals to the servos based on the program uploaded. The PCA 9685 is used to connect the positive and the ground wires to the positive and the negative rail in the PCA9685.

Each servo lifts the leg swings it forward and places it down completing one step cycle. As the robot moves when it receives the command to activate the automatic mode the ultrasonic sensor gets activated and the robot starts moving and just avoids if any of the obstacle is detected near by and navigates accordingly.

Table -1: Observation of Obstacle Avoidance

Obstacle Distance	Robot Response
15 cm	Stopped
10 cm	Turned left/right
25 cm	Continued moving

6. RESULTS

The robot was able to walk smoothly on rough surfaces and small obstacles. It successfully detected objects using the ultrasonic sensor and changes its moments by renavigating to avoid them. The walking pattern worked properly and the mechanical design remained stable during the final testing. In the beginning I faced a many problems because the

walking moments wear not proper and not matching as we planned and the robot was also not standing correctly when one leg lifts up to move forward and then slowly analyzing the problem by calibrating each step and leg then the robot worked successfully in which the camera module also worked properly by streaming live video to record .Overall, the prototype performed well in terms of mobility, balance and obstacle navigation.

7. CONCLUSION

The spider robot project successfully shows how mechanical design, electronics and programming can be integrated to create a remote controlled robot that mimics a spider walking pattern. The project successfully performed all the operations as per planned and performed the walking tasks on rough surfaces and also navigates when an obstacle mode is turned on and the camera module successfully records and Strems live video successfully.

8. REFERENCES

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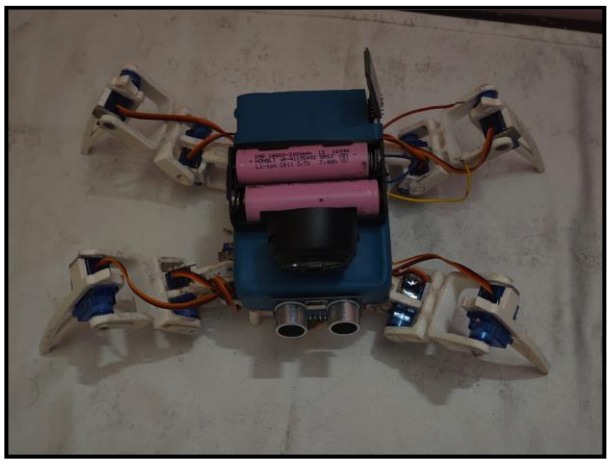
Appendix- Photographs of Prototype



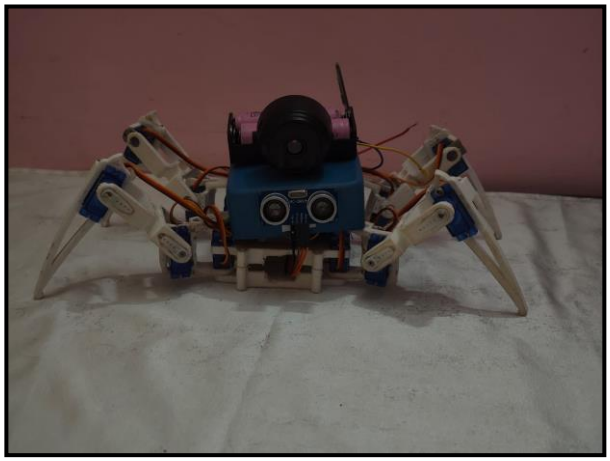


Fig -10: Prototype