INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact Factor: 6.078
(Volume 11, Issue 2 - V11I2-1286)
Available online at: https://www.ijariit.com

Obstacle Avoiding Arduino Controlled Bipedal Robot

Kalyani Anumalla
anumallakalyani7@gmail.com
MCT's Rajiv Gandhi Institute of Technology, Mumbai, Maharashtra

Bhoomi Gupta
guptabhoomi677@gmail.com
MCT's Rajiv Gandhi Institute of Technology, Mumbai, Maharashtra

Mohd. Ajmal Javed
javedajmal18@gmail.com
MCT's Rajiv Gandhi Institute of Technology, Mumbai, Maharashtra

Prof. Nikhil VS
nikhil.vs@mctrgit.ac.in
MCT's Rajiv Gandhi Institute of Technology, Mumbai, Maharashtra

ABSTRACT

This paper presents the design and development of an Arduino-controlled bipedal robot with integrated obstacle avoidance. The robot simulates human walking using servo motors and executes real-time path adjustments based on ultrasonic sensor input. Inverse kinematics principles guide the movement, and the structure is fabricated using PLA-based 3D printing for lightweight and modular design. The system demonstrates efficient coordination of mechanical, electronic, and software elements for autonomous walking and navigation in dynamic environments.

Keywords: *Arduino, Bipedal Robot, Obstacle Avoidance, Inverse Kinematics, Servo Motor*

INTRODUCTION

Bipedal robots replicate human walking through the coordinated motion of two legs. This project focuses on developing a low-cost, autonomous bipedal robot that integrates an Arduino Uno controller, six MG996R servo motors, and an ultrasonic sensor for obstacle detection. The robot is designed to traverse basic terrains while avoiding obstacles in real time. With lightweight PLA parts and a modular 3D-printed frame, the robot is engineered for stability, efficiency, and upgradability. It combines mechanical design, inverse kinematics, and embedded control to achieve stable motion.

Problem definition

Stability, terrain adaptability, and real-time responsiveness are major challenges in bipedal robotics. Traditional humanoid systems require complex algorithms and costly sensors. This project takes a minimalistic approach by using affordable components and programmed servo motion. The focus lies on maintaining balance, achieving synchronized servo control, and enabling obstacle-aware decisions through sensor data.

Objectives

Develop a bipedal robot with walking and obstacle-avoidance capabilities.
Use Arduino Uno and six servo motors to simulate human-like walking.
Integrate ultrasonic sensor input for real-time navigation decisions.
Apply inverse kinematics for motion calculation.
Build a lightweight and modular 3D-printed frame.

Working principle

The robot's core control unit, an Arduino Uno, interprets ultrasonic sensor data and adjusts servo motor angles accordingly. Using PWM signals, the Arduino commands each servo to shift the robot's legs in a coordinated manner based on inverse kinematics. When an obstacle is detected within 15 cm, the robot steps back, turns randomly, and resumes walking. This loop runs continuously, allowing real-time adaptation and smooth locomotion

Methodology

The robot consists of two legs with three degrees of freedom each—hip, knee, and ankle. The frame was designed in SolidWorks and fabricated using 3D printing with PLA. The MG996R servos are placed to mimic human joint articulation. Arduino code defines movement patterns, while ultrasonic sensors provide obstacle data. The inverse kinematics model calculates joint angles required for foot placement.

Servo motor control

Standard PWM servo control is implemented using Arduino's Servo.h library. MG996R servos respond to pulses between 1ms and 2ms for 0° to 180° range. Arduino pins are mapped to individual joints, and the motion sequence is defined through coordinated write commands and delay timing.

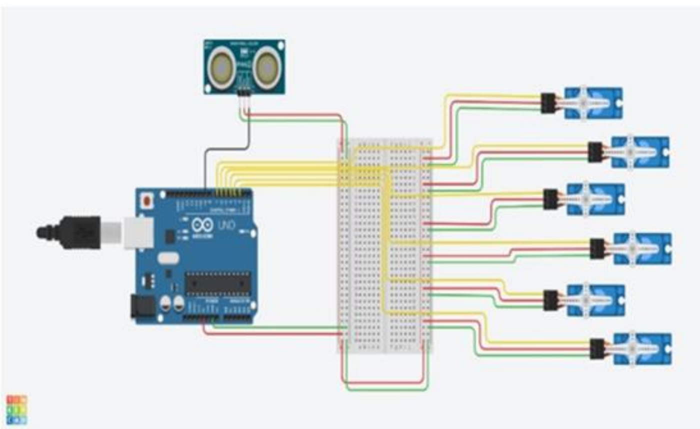


Fig: Circuit diagram we made on Tinkercad

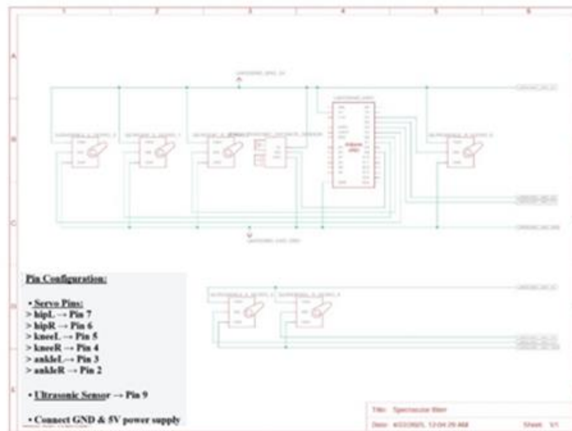
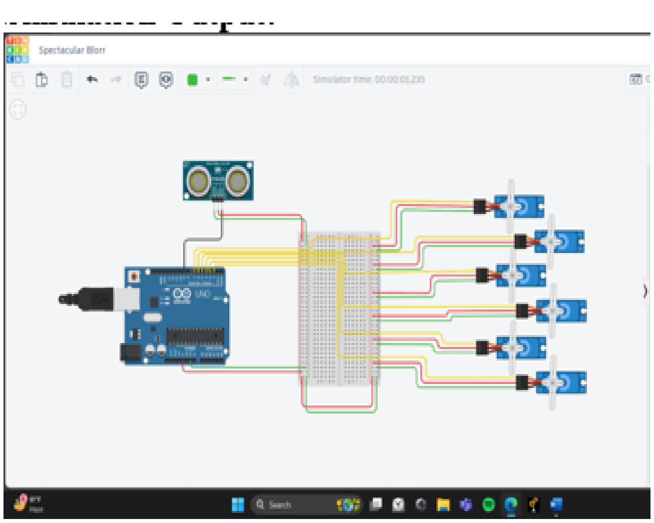


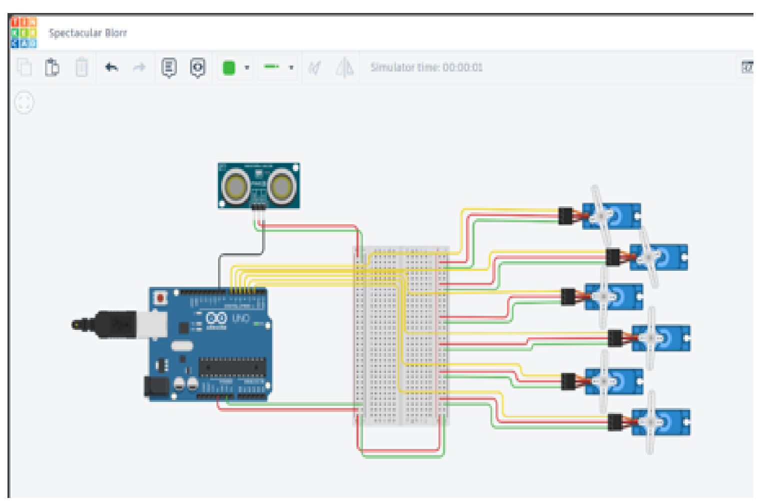
Fig: Schematic & Pin configuration

Code Output:

The robot stands straight, then starts walking forward step by step. If it detects an obstacle, it backs up, turns left or right randomly, and keeps walking forward again. This cycle continues as long as it runs.

Simulation Output:





CALCULATION

Motion paths are calculated using inverse kinematics for a 2-link planar leg. By inputting target (x, y) foot coordinates, the system solves for joint angles using trigonometric laws. Optional ankle compensation ensures the foot remains parallel to the ground during walking.

Design procedure

Legs designed in SolidWorks around servo placements.

Brackets and bearings added for joint stability.

Compact body houses electronics and ensures center alignment.

CAD features included tolerance control and wire-routing channels.

Custom foot pads distribute weight and improve balance.

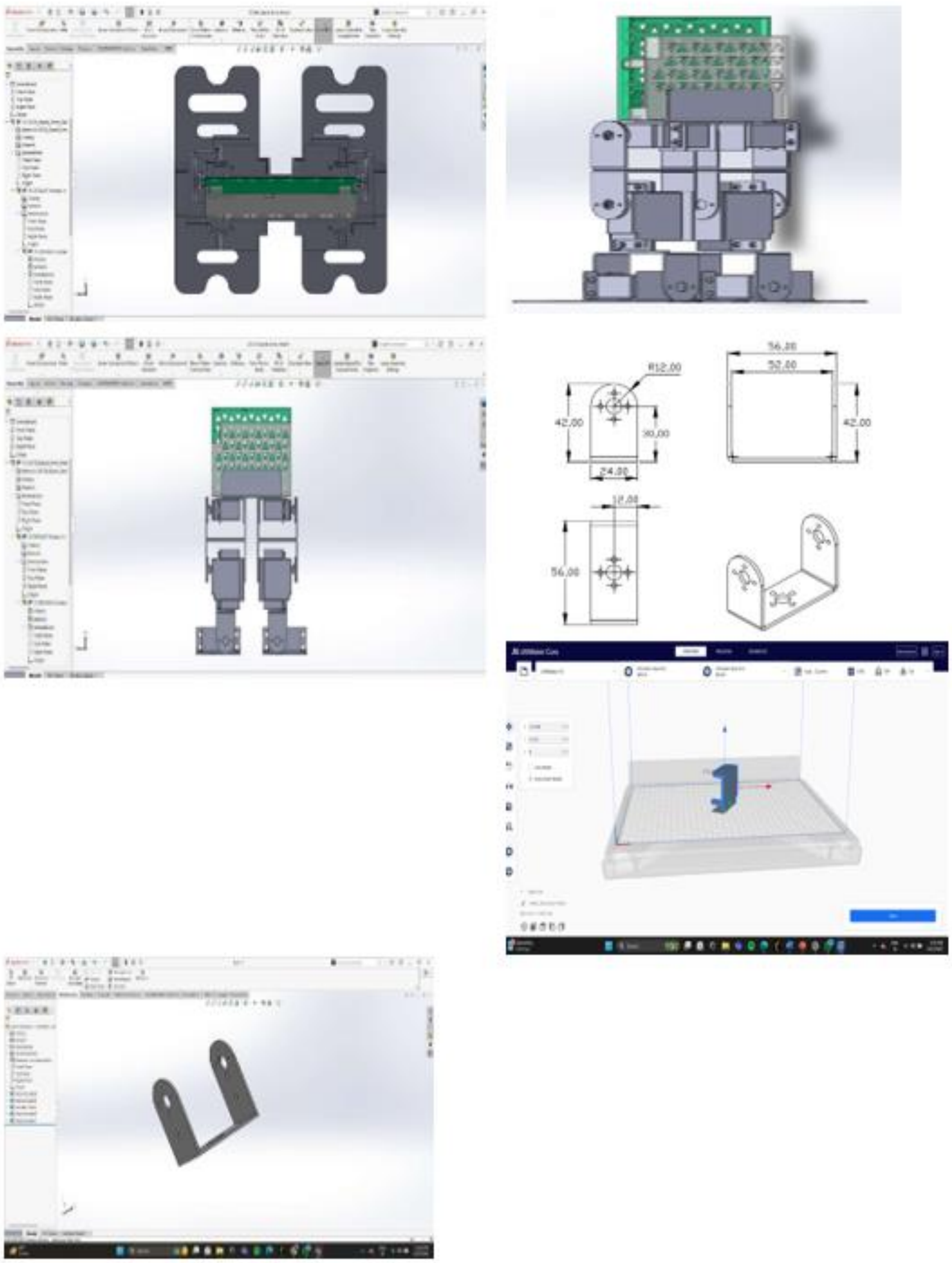


Fig: Few CAD models & STL images

Components used
Electronics:
Arduino Uno R3
HC-SR04 Ultrasonic Sensor
6x MG996R Servo Motors
External 6V 2A Power Supply

Mechanical:
PLA 3D-Printed Body Parts
Bearings (6mm ID), Bolts, Nuts
Breadboard, jumper wires
Estimated Budget~ Rs. 4000 /-
2.3 Advantages
Affordable platform for robotics education.
Combines real-world design with sensor-based decision-making.
Reinforces understanding of inverse kinematics and automation.
Encourages teamwork and practical innovation.

CONCLUSION

This project successfully implemented a cost-effective bipedal robot capable of walking and avoiding obstacles. Using Arduino Uno, servo motors, ultrasonic sensing, and inverse kinematics, the robot achieves autonomous movement. It integrates design, coding, and motion control—offering a foundation for future robotic applications and learning.

The project titled "Study and Designing of Obstacle-Avoiding Arduino-Controlled Bipedal Robot" was aimed at developing a biomechanically inspired robotic leg structure with three degrees of freedom per leg, designed in SolidWorks. Key features included bearing-supported links, dual-shaft mounting brackets, and optimized link lengths for efficient movement. The structure was intended to be 3D-printed using PLA, with provisions for housing electronic components compactly.

Although physical fabrication could not be carried out due to certain constraints, the electrical circuit was successfully simulated using Tinkercad, Arduino coding was implemented, and detailed CAD models were developed and converted to STL format. Material selection, component research, and budgeting were also completed. Hence, the project objectives related to design, simulation, and planning were successfully achieved.

Components used
6x Standard Servo Motors
RP2040 PicoW Board
Skateboard Bearings (8x19x7mm)
M4 nuts and bolts, PLA filament (3D-printed)
Servo holders, bridges, and mounts designed for structural integrity

Advantages
Practical exposure to robotics and automation
Cost-effective learning platform
Deepens understanding of human locomotion and IK
Teamwork and engineering skills enhanced

Conclusion

The Arduino-based bipedal robot project successfully demonstrated stable and functional walking using simple, cost-effective components. By integrating servo motors with a microcontroller and applying principles of inverse kinematics, the robot was able to perform basic locomotion and directional movements. The project offered valuable hands-on experience in mechanical design, motion control, and programming, making it an excellent learning platform for students interested in robotics. It also sets a strong foundation for future exploration in humanoid automation, assistive technology, and AI-enhanced mobility systems.

REFERENCES

[1] Arduino Official Documentation – Servo Library
[2] Autodesk Instructables – Arduino Controlled Robotic Biped

[3] J. Pratt et al., "Series Elastic Actuators for Bipedal Walking," IEEE RAM, vol. 15, no. 3, 2008.
[4] J. H. Park, "Impedance Control for Biped Robot Locomotion," IEEE Transactions, vol. 17, no. 6, 2001.
[5] T. McGeer, "Passive Dynamic Walking," IJRR, vol. 9, no. 2, 1990.