**COUNCIL ON SCIENCE AND GUJARAT TECHNOLOGY**

Dept. of Science and Technology, Govt. of Gujarat

**FINAL TECHNICAL REPORT SUBMISSION FOR LEVEL-III “PROTOTYPE” OF ROBOFEST-GUJARAT 4.0**

1**. Description of Robot**

In the dynamic and rapidly advancing field of robotics, the need for machines capable of adapting to diverse environments and addressing complex challenges is paramount. Our proposed hexapod robot embodies this vision, representing a cutting-edge solution that integrates advanced mobility, adaptability, and autonomous functionalities into a singular, highly versatile platform.

This six-legged robot, known as a hexapod, is meticulously designed to traverse a wide variety of terrains with exceptional agility and stability. Drawing inspiration from biological locomotion, the robot is equipped with six independently controlled legs, each featuring multiple degrees of freedom to ensure precise movement and balance in challenging environments. A defining feature of this innovative design is its ability to seamlessly transition between walking and rolling modes. This dual-mode locomotion system allows the robot to efficiently navigate both rugged terrains and smooth surfaces, significantly enhancing its operational versatility.

The robot's advanced sensor suite, comprising LIDAR, and high-resolution cameras, enables a high level of environmental awareness, facilitating autonomous navigation and obstacle avoidance. These capabilities make the hexapod ideal for a range of applications, including search and rescue missions, planetary exploration, agricultural automation, and industrial inspection tasks. This state-of-the-art robotic system reflects the forefront of engineering innovation and underscores the transformative potential of modern robotics in addressing critical challenges across various sectors.

**2. Salient Features of the Hexapod Robot**

Below are the key features that make this hexapod robot a groundbreaking solution in the field of robotics:

1. **Dual-Mode Locomotion:** The robot features a dual-mode locomotion system, allowing it to seamlessly switch between walking and rolling modes. In walking mode, the six-legged design helps it navigate uneven, rugged, and soft terrains that would be challenging for wheeled robots. In rolling mode, it transforms into a compact cylindrical form, enabling fast and efficient rolling movement over smooth surfaces. This unique capability ensures that the hexapod can adapt to a wide variety of environments, from rocky landscapes to flat pavements, offering remarkable versatility for diverse applications. The transition to walking mode is automatically triggered when obstacles or uneven surface are detected.
2. **Efficient walking**: The hexapod is equipped with six high-torque servo motors driving its legs, providing exceptional stability and maneuverability. It supports multiple gait patterns, including the tripod gait, where three legs move simultaneously to maintain balance. This enables smooth and stable walking, even in challenging conditions. The robot’s walking system is adaptable to various terrains, adjusting in real-time based on data from onboard sensors, ensuring that it can handle everything from rocky paths to soft soil with precision and stability.
3. **Rolling Capability**: In rolling mode, the robot utilizes an outer disk mechanism powered by DC motors to roll across flat surfaces with high efficiency and speed. The rolling mode allows for rapid movement over long distances, which is particularly useful for exploring large areas or when speed is crucial. During this phase, the robot’s legs are securely retracted, and the central body remains forward-facing, ensuring stability and directional control.
4. **Climbing Ability**: The hexapod robot excels at climbing obstacles such as stairs and ledges. Its servo-powered legs, combined with high-torque DC motors, provide the necessary strength to lift and maneuver the body over obstacles. This climbing capability extends the robot's reach in environments that require overcoming vertical challenges, making it ideal for search-and-rescue operations or industrial inspections where uneven terrain is common.
5. **Independent Leg Control**: Each of the six legs of the hexapod is independently controlled, providing the robot with precise coordination and the ability to adjust its movements to maintain balance on uneven or unstable surfaces. This feature allows the robot to step over gaps, climb obstacles, and adapt its gait dynamically to the conditions it faces. The ability to control each leg independently also ensures that the robot can handle unpredictable terrains with ease.
6. **Advanced Sensor Suite**: The robot is equipped with a range of sensors, including ultrasonic sensors for distance measurement, LIDAR for mapping and navigation, and high-resolution cameras for real-time image processing. These sensors enable the robot to detect obstacles, create detailed maps of its environment, and make intelligent, autonomous decisions based on real-time input, making it capable of navigating complex environments autonomously.
7. **Autonomous Operation**: Powered by advanced artificial intelligence algorithms, the hexapod operates autonomously, analyzing its environment and adapting to changes without requiring constant human intervention. It can plan optimal paths, avoid obstacles, and make real-time adjustments, making it ideal for operations in remote or dangerous locations where human presence is not feasible or safe.
8. **High Stability and Agility**: The hexapod's six-legged configuration ensures excellent stability, even in challenging conditions. The robot’s design allows it to perform agile movements, such as climbing obstacles, maneuvering in confined spaces, and executing smooth and coordinated motions. This balance of stability and agility ensures reliability in complex and dynamic environments.
9. **Energy-Efficient Design**: The hexapod robot is engineered for energy efficiency, ensuring optimal performance while conserving power. The robot intelligently switches between walking and rolling modes to minimize energy consumption during travel, which is particularly beneficial for long-duration missions or in energy-limited environments like space exploration.
10. **Robust and Durable Build**: Built from high-strength aluminum, the hexapod robot is designed to withstand extreme environmental conditions. It is resistant to factors such as temperature fluctuations, moisture, dust, and mechanical stress, ensuring reliability in outdoor, industrial, and extraterrestrial environments.

These features combine to make the hexapod robot a highly advanced, adaptable, and reliable solution for a wide array of applications in the robotics field.

3. **Description of Mechanical Design.**

**1. Frame Structure:**

The robot's frame consists of two circular aluminum end plates connected by a central aluminum rod. The key components are:

- Inner circular aluminum plates supporting DC motors

- Outer circular aluminum plates with integrated gear teeth for servo motor connections

- Aluminum frame and 3D printed components forming the structural legs

- Central mounting rod providing structural integrity

**2. Drive Mechanism**

**2.1 Gear System**

**- Outer aluminum plates feature inner gear teeth on the reverse side**

**- Spur gears mesh with inner teeth for power transmission**

**- DC motors drive the spur gears for wheel rotation**

**- Precision bearings mounted in plate centers ensure smooth motion**

**2.2 Power Transfer**

**- Wire slip ring fitted on central rod enables continuous rotation**

**- Bearings connect plates to central rod**

**- Identical drive systems on both ends maintain symmetry**

**- Servo motors connect to outer plates via aluminum linkages**

**3. Electronics Housing**

**- Central 3D printed plate houses electronic components:**

**- Main processor**

**- Motor drivers**

**- Buck converter**

**- Battery compartment**

**- Structured cable management through central rod**

**4. Stopping Mechanism**

**- Located on bottom of middle plate**

**- Consists of:**

**- Servo motor for actuation**

**- Free wheel for ground contact**

**- Provides stability and controlled stopping**

**6. Materials**

**- Primary structure: Aluminum plates and frame**

**- Support components: 3D printed ABS/PLA**

**- Motion components: Steel bearings and gears**

**- Central shaft: Aluminum rod**

**- Electronic housing: 3D printed enclosure**

1. **Frame Construction and Core Architecture:**

The robot's fundamental structure is engineered around a sophisticated dual-plate system interconnected by a central aluminum rod. Each end of the robot features precisely machined circular aluminum plates that serve multiple functions. The inner circular aluminum plates are meticulously designed to provide robust support for the DC motors, incorporating mounting points that ensure optimal motor positioning and stability during operation. The outer circular aluminum plates, which form the visible exterior of the robot, are engineered with integrated gear teeth patterns on their interior faces. These gear patterns are precision-machined to ensure smooth mesh with the drive system and maintain consistent power transmission throughout rotation.

The structural integrity is further enhanced by an intricate network of aluminum frame members that form the robot's legs. These aluminum components are supplemented by custom-designed 3D printed parts that serve as interface points between the servo motors and the frame. This hybrid approach combines the strength and reliability of aluminum with the complex geometries possible through additive manufacturing, resulting in a structure that is both robust and adaptable.