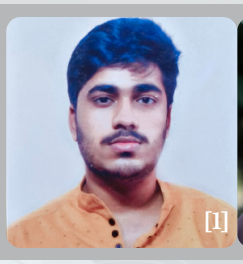
CERBRUS: An Open-Source Quadruped Robot with a Front-Mounted Gripper Inspired by Ant Morphology

KID: 20240402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Inspired by the functional anatomy of ants, CERBRUS is an open-source quadruped robot equipped with a front-mounted gripper designed for mobility and manipulation in constrained environments.

Unlike traditional quadruped robots that mount manipulators on the torso or back, CERBRUS integrates the gripper at the front "mouth" area, mimicking the ant's mandibles. This bio-inspired design streamlines interaction with the surroundings while improving balance and reducing mechanical complexity.

The motivation stems from the limitations of conventional designs, such as shifting centre of mass and reduced reach, which complicate locomotion and interaction in narrow spaces. Drawing from nature, CERBRUS proposes a compact alternative that blends locomotion with manipulation capabilities in one elegant, insect-like form.

Mechanically, CERBRUS is designed using SolidWorks and optimized through several iterations to balance weight and strength. The final structure measures 550 mm in length, with a 300 mm shoulder width and weighs approximately 3.6 kg. Structural analysis under a 20N load for each leg has been carried out, indicating a load-bearing capacity of up to 8 kg (80N) considering all four legs. The gripper, actuated via servo-driven gears, offers 2 degrees of freedom and rubber-ended tips for better grip, suitable for simple pick-and-place tasks.

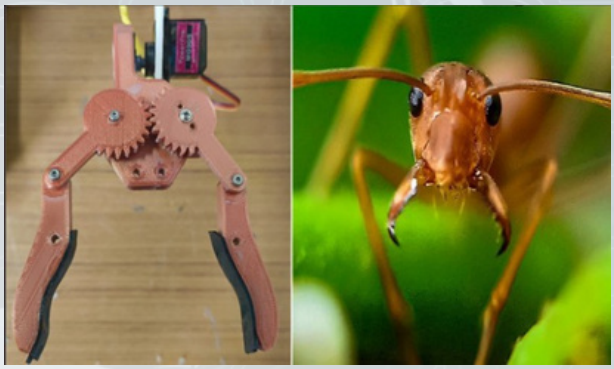

Figure 1: Comparison of the designed Gripper and an Ant for reference

Electronically, CERBRUS is powered by a Raspberry Pi 5 paired with Arduino Mega and Nano boards. A variety of sensors, including BNO055 IMU and voltage sensors, support telemetry and stabilization. Communication between the robot and its custom-built controller is handled via HC-12 radio modules. The controller features joysticks, potentiometers, and a touchscreen LCD interface, making the system fully interactive and field- ready. The software stack is built around ROS2 (Jazzy), hosted on Ubuntu 24.04, with modular packages handling tasks like gait control, hardware interfacing, pose estimation, and fall recovery.

Custom ROS messages streamline data transmission, while nodes such as commander-node and pose-detect-node manage locomotion and visual feedback. A PID-based balancer maintains robot orientation, actively adjusting leg heights to stabilize the robot in real-time.

In terms of motion, CERBRUS employs a trot gait, where diagonal pairs of legs move simultaneously. Cycloidal trajectories have been implemented to create smooth, biologically inspired footpaths. Trajectory generation scripts are optimized for control loop frequencies of up to 103 Hz, offering real-time responsiveness.

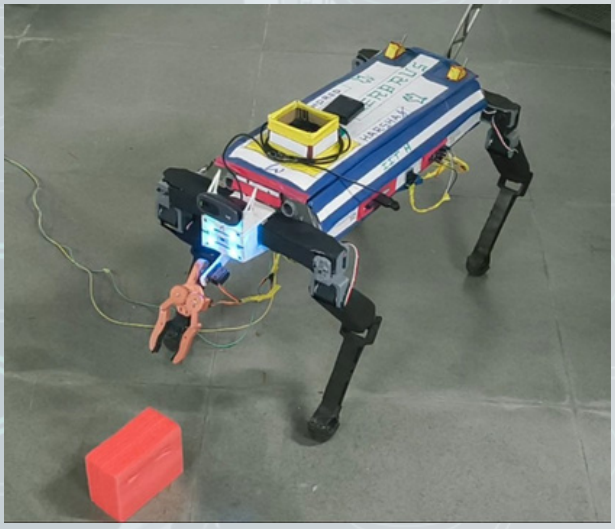

Figure 2: Final Design of the Robot

A key highlight is the project's modularity. The user guide enables seamless operation from boot-up to execution, and a dedicated developer mode allows for code modifications via SSH or HDMI interfaces. The robot's capabilities were validated through indoor and outdoor testing across different terrains.

CERBRUS bridges a critical gap in mobile robotics by fusing bio-inspiration with robust design and open-source accessibility. It holds potential for applications in search and rescue, exploration, and other domains where volume, weight, and environmental interaction are crucial.

Future directions include enhancing autonomy with sensors like LiDAR, integrating machine learning for gait optimization, and exploring swarm robotics to enable cooperative robotic behaviors.

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