PHOENIX: Perching Hybrid Omni Environment Navigation Integrated eXplorer: A Modular Aerial-Ground AI-Based Biomimetic Robotic System for Two-Body Locomotion

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The need for efficient, actuated robotic systems has increased with modern integration, disaster relief scenarios, and stealth tech. The Perching Hybrid Omni-environment Navigation Integrated eXplorer is a modular aerial-ground robot system developed to investigate novel two-body locomotion through a land-based autonomous quadruped platform. PHOENIX is an original quadruped with an integrated docking interface, positioning the ground system as the primary base responsible for terrain navigation, aerial tracking, docking, and data collection. Empirical data is collected from joint encoders, custom actuator torque sensors, inertial measurement units, force-feedback, and a vision systems to evaluate gait stability, energy efficiency, and docking precision in real world conditions. A virtual training environment was used to train machine learning models for embodied locomotion and docking behaviors, which are put into practice deploying the physical quadruped, enabling virtual to real world application. The aerial vehicle functions as a cooperative system designed to interface with the ground platform, allowing ground-air coordination performance (docking and local information transfer). Key variables analyzed include actuator torque, back drivability, power consumption, terrain time, along with ground reaction, actuation, and contact recovery time following disturbances. PHOENIX is equipped with a voice module and speaker for voice commands and directions (onboard GPU), and processing sensors for real-time joint feedback, which show a new standard for smart robots. By prioritizing custom actuator design and autonomous docking, along with a 12 DoF original quadruped, PHOENIX addresses a largely unexplored challenge in linking robotics interfaced with physical AI elements.

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