ABSTRACT OF THE DOCTORAL RESEARCH PROJECT

From elephant trunk to robotics: an interdisciplinary approach to bio-inspired solutions

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ABSTRACT

The elephant trunk, a remarkable muscular hydrostat, serves as a groundbreaking model for developing bio-inspired robotic solutions. Capable of powerful and precise movements without any rigid skeletal structure, the trunk demonstrates exceptional versatility through its ability to wrap around objects, manipulate deformable materials (e.g., grass), and use suction for lifting smaller items. These unique features make it an ideal model for designing robotic systems that combine strength, precision, and adaptability, qualities often lacking in current industrial robots.

This project aims to quantify the behavioral, anatomical, and biomechanical properties of the African elephant trunk to understand how it achieves such complex functionalities. Key parameters such as elongation, shortening, bending, twisting, and suction will be analyzed, alongside dynamic studies of fluid manipulation (e.g., water suction, airflow control) and surface interaction (e.g., adhesion on irregular surfaces, vibration response). By exploring how the trunk adjusts its strategies based on material properties (e.g., deformability, texture) and environmental conditions, this study will uncover the mechanisms behind its unparalleled stability, control, and adaptability.

The insights gained will inform the design of two innovative robotic prototypes based on tensegrity principles, combining compressive and tensile elements to create lightweight, flexible, and energy-efficient structures.

The first prototype will feature a prehensile tip/hand replicating the trunk's fine motor skills, while the second will embody a kinematic architecture mimicking its body's behavior as a multi-jointed arm capable of transmitting high forces without rigid vertebrae.

Together, these prototypes will form a versatile robotic system capable of advanced grasping techniques, suction-based stabilization, and adaptive manipulation of objects with varying properties.

What sets this system apart is its integration of a wide range of biomechanical and morpho-functional data, such as suction for object stability, surface adhesion to prevent slippage, and vibration-based sensing for enhanced environmental interaction. This bio-inspired approach, rooted in tensegrity and biomimicry, promises to revolutionize robotic systems, enabling applications in industries requiring precise, adaptable, and robust manipulation, from logistics to healthcare.