MUR
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Research project

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Title: Fluid-structure interaction modeling of bioinspired soft robots

Description:

In recent years, there has been a growing interest in drawing inspiration from nature to design engineering systems that incorporate flexible structures. Natural flyers and swimmers—such as fish, birds, and insects—demonstrate remarkable efficiency in navigating vortex-dominated environments, often utilizing structural flexibility to enhance propulsion and maneuverability. As such, understanding vortex-dominated flows is essential for advancing both the aerodynamics and hydrodynamics of biological and bioinspired systems.

Unlike traditional robots composed of rigid links and joints, soft robots are made from compliant materials that allow for continuous, adaptable deformation. These systems exploit high degrees of freedom in shape morphing, enabling versatile and responsive functionalities. A key challenge lies in identifying the optimal balance between flexibility and structural integrity to maximize performance in dynamic flow conditions. Current research is at the forefront of exploring flexible materials and morphing structures that can respond intelligently to environmental stimuli. Insights gained from studying vortex interactions with bioinspired structures have broad applications, including in aerospace, marine engineering, biomedical devices, and renewable energy technologies.

Despite recent advancements, the widespread adoption of these systems remains limited, primarily due to the absence of systematic design methodologies. Instead, development often relies on costly and time-consuming trial-and-error processes. This project aims to address this gap by developing and applying advanced in silico multiphysics simulation tools to model the biomechanical behavior of both natural and engineered soft robotic systems.

The Fluid Dynamics Research Group at Politecnico di Bari has recently developed high-fidelity multiphysics simulation platforms capable of modeling fluid-structure interactions involving soft robots across various configurations. These tools integrate state-of-the-art computational techniques from the fields of fluid dynamics, structural mechanics, and electrophysiology. The proposed research will leverage these tools to optimize the design and forecast the performance of bioinspired devices. The outcomes will include the identification of optimal robotic configurations and the establishment of rational design guidelines. This approach will significantly reduce reliance on costly experimental procedures, facilitating more efficient development cycles and enabling broader adoption of soft robotic technologies in real-world applications.

Candidates should provide detailed CV

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