Politecnico di Torino

SUSTAINABLE MATERIALS, PROCESSES AND SYSTEMS FOR ENERGY TRANSITION

DIMEAS / Novel methodologies for mooring system analysis in wave / wind energy systems.

Funded By	Dipartimento DIMEAS

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Context of the research activity	This research aims to develop advanced integrated control strategies for wave and wind energy systems, emphasizing the optimization of mooring dynamics and energy harvesting efficiency. The study will employ machine learning and artificial intelligence techniques to create adaptive control systems that respond to real-time environmental conditions, enhancing the overall performance and reliability of renewable energy devices.

	As the demand for renewable energy sources grows, wave and wind energy systems are gaining prominence. However, the complex interactions between these systems and their mooring setups remain a significant challenge, often leading to suboptimal energy harvesting. This research proposes to advance the current understanding and technology by integrating modern computational techniques to optimize control systems and mooring dynamics. Objectives: • Machine Learning for Mooring Dynamics: To apply machine learning algorithms for predicting and optimizing the impact of mooring dynamics on device performance. • AI-based Adaptive Control Systems: To develop adaptive control systems using artificial intelligence that can dynamically adjust to changing environmental conditions. • Optimization of Hybrid Energy Systems: To optimize the performance of combined wave and wind energy systems through integrated control and mooring design. • Real-Time Environmental Adaptation: To enhance energy harvesting efficiency by enabling real-time adaptation to environmental changes. • Experimental and Numerical Validation: To validate the proposed models and control strategies through rigorous experimental and numerical testing. Research Activities: 1. Development of Machine Learning Models: a. Develop predictive models using machine learning to forecast mooring system impacts on energy device performance. b. Train models on historical data and validate against experimental results.

Objectives	2. AI-based Control System Design: a. Design adaptive control systems that utilize AI to optimize energy harvesting by adjusting to real-time conditions. b. Implement reinforcement learning algorithms to enable continuous improvement of control strategies. 3. Hybrid Energy System Optimization: a. Integrate wave and wind energy systems into a unified model to study their combined dynamics and optimize overall performance. b. Conduct simulations to identify optimal configurations and control parameters for hybrid systems. 4. Real-Time Environmental Adaptation: a. Develop sensors and monitoring systems to collect real-time environmental data. b. Implement control algorithms that adapt device operations based on real-time inputs, maximizing energy capture and minimizing wear and tear. 5. Experimental and Numerical Validation: a. Conduct experiments in controlled environments such as wave tanks and wind tunnels to validate model predictions. b. Use numerical simulations to further refine models and control systems. This research aims to make significant advancements in the field of renewable energy by: • Introducing machine learning and AI techniques to optimize mooring dynamics and energy harvesting. • Developing adaptive control systems that enhance the performance and reliability of wave and wind energy devices. • Optimizing the integration of hybrid wave and wind energy systems for maximum efficiency. • Validating innovative models and control strategies through rigorous experimental and numerical testing. • Contributing to the commercialization of advanced renewable energy technologies through collaboration with industry partners. Ultimately, this research will support the advancement of renewable energy technologies, promoting their efficiency, reliability, and commercial viability in the pursuit of a sustainable energy future.

Skills and competencies for the development of the activity	The ideal candidate should have a background in renewable energy systems and experimental testing. Proficiency in experimental prototype, numerical modelling and data analysis is beneficial. Experience with modern control techniques applied to WEC and wind turbine desirable. The candidate should possess strong analytical skills, attention to detail, and the ability to work independently and collaboratively in an interdisciplinary and international research environment.