

GRADIENT-FLOW OPTIMIZATION OF LAYOUT CONTROL DESIGN OF WAVE ENERGY PARKS

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Abstract

Wave energy converters (WECs) are a promising technology for renewable marine power generation, yet the limited output of single devices requires their deployment in large-scale parks to ensure economic viability. The optimal design of WEC parks is a challenging high-dimensional problem involving the simultaneous optimization of device layout and control parameters under hydrodynamic, dynamic, and geometric constraints.

We propose a novel numerical framework based on a gradient-flow formulation for the combined layout-control optimization of wave energy parks. The resulting evolution problem is integrated using an adaptive low-order Runge-Kutta scheme coupled with an inexact solution strategy that automatically adjusts solver tolerances to avoid oversolving and minimize parameter tuning. The objective is the maximization of the average power production while enforcing constraints on available sea area, minimum device distance, and bounded oscillation amplitude.

Analytical computation of the Jacobian and simulations with realistic parameters demonstrate the efficiency, robustness, and physical relevance of the proposed approach, enabling effective large-scale optimal design of WEC parks.

Keywords: wave energy converters, nonlinear optimization, gradient-flow, WEC layout and control optimization

References

[1] Gambarini M., Ciaramella G., Miglio, E. , A Gradient Flow Approach for Combined Layout-Control Design of Wave Energy Converters, SIAM J. Sci. Comp., 2026.