

XI International Conference on Computational Methods in Marine Engineering
Simultaneous Optimization of Hydrofoil Design and Control Strategies:
Application to a Pumping Foiler

Antoine Guillou¹, Fabien Cockenpot¹ and Giovanni Bailardi²

¹ Pitch Perfect Engineering,
56100 Lorient, France

² Bailardi Engineering,
46001 Valencia, Spain

ABSTRACT

Optimizing marine vehicle designs, particularly hydrofoils, has traditionally relied on quasi-static methods focused on steady-state conditions (Bailardi et al. 2015, Tannenber et al. 2023, Solak et al. 2024). However, these approaches overlook dynamic effects and time-varying response in waves, gusts and manoeuvring scenarios. Alternatively, dynamic simulators allow to evaluate design candidates under such conditions, but do not allow for design optimization. This study introduces a holistic approach by optimizing the hydrofoil design and the control law simultaneously to more accurately represent operational conditions.

The simulation is based on a multibody model that integrates a simplified human submodel representing the rider and an unsteady, nonlinear lifting line to capture the foil's hydrodynamic response. An optimal control problem is formulated to solve for the optimum foil design and the corresponding rider choreography.

Using an endurance contest as a test case, the study optimizes a classic front-wing and stabilizer configuration to minimize the rider's energy consumption during a pumping cycle. The best candidates are compared against quasi-static optimums and a multi-fidelity analysis is performed to evaluate the impact of the flow solver accuracy on the foil design.

References

- G. Bailardi, J. Guerrero and D. Natali. On the Fluid Dynamic Design and Optimization of Sailing Yachts Hull and Appendages using a Complete Open Source Framework. In MARINE 2015 - Computational Methods in Marine Engineering VI.
- R. Tannenber, S. R. Turnock, , K. Hochkirch, and S. W. Boyd. VPP Driven Parametric Design of AC75 Hydrofoils. In Journal of Sailing Technology 8 (2023): 161–182. doi: <https://doi.org/10.5957/jst/2023.8.9.161>
- H. P. Solak, J. Wackers, R. Pellegrini, A. Serani, M. Diez, P. Perali, M. Sacher, J-B. Leroux, B. Augier, F. Hauville, P. Bot (2024). Optimising hydrofoils using automated multi-fidelity surrogate models. Ships and Offshore Structures, 1–12. <https://doi.org/10.1080/17445302.2024.2422518>