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ARTIFICIAL INTELLIGENCE AND PHYSICS-INFORMED MODELS FOR HULL AND PROPELLER DESIGN BY OPTIMISATION

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ABSTRACT

Optimizing the shape of vessel hulls and propellers is critical for achieving the best performance and reducing environmental impact. Typically, the design process involves modifying existing models to better meet specific Key Performance Indicators, such as hull drag, airfoil lift and drag, noise, and cavitation, through a mix of human expertise and numerical optimization.

Currently, state-of-the-art methodologies for these tasks employ Artificial Intelligence (AI)-based data-driven surrogates to estimate the performance of candidate designs based on a limited number of computational fluid dynamics (CFD) simulations. Researchers have investigated using AI-based techniques that, while exhibiting lower accuracy compared to the classical computational fluid dynamics-based approaches, have the advantage of being extremely fast. To address the lack of accuracy, physics-informed AI techniques, i.e., techniques that leverage both the data and domain knowledge to generate simultaneously fast and accurate models, have been proposed recently. However, these works are often limited by the fact they do not fully leverage physical knowledge in the surrogate.

This Invited Session aims to showcase recent advances in this field of research with a focus on the use of AI and physics-informed models for hull and propeller design by optimisation.The key objective of this session is to promote discussion about the capabilities, challenges of AI techniques that include domain knowledge for the design of hulls and propellers.

Therefore, we invite contributors on applications of AI techniques in marine engineering to improve knowledge in the field, showing new ideas, applications, and challenges.

Topics

Fundamentals of AI in Marine Design:

- Introduction to AI and data-driven surrogates in marine engineering.
- Overview of computational fluid dynamics (CFD) for vessel design.

- The role of machine learning in predicting hull and propeller performance.

Physics-Informed Machine Learning Models:
- Bridging data-driven models with physical knowledge for marine design.
- Case studies on physics-informed models for optimizing hull shapes and propellers.

Optimization of Hull Design for Performance and Sustainability:
- Strategies for reducing hull drag and enhancing fuel efficiency using AI.
- Innovations propeller shape design for minimizing environmental impact.
- Comparative analyses of AI-driven vs. traditional methods in hull optimization.

Propeller Design and Optimization Techniques:
- AI applications in propeller design for improved efficiency and reduced cavitation.
- Exploration of new materials and geometries for propellers through AI models.
- Challenges and solutions in simulating and optimizing propeller noise.

Integration of AI with Computational Fluid Dynamics:
- Hybrid models combining AI with CFD for enhanced prediction accuracy.
- Addressing the challenges of scale and complexity in fluid simulations with AI.
- Case studies on successful integrations of AI in CFD for marine applications.

Emerging Technologies and Future Directions:
- Next-generation AI techniques for marine engineering (e.g., deep learning, reinforcement learning).
- The potential of digital twins in designing and testing hull and propellers.
- Future challenges and opportunities in the integration of AI in marine design.