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TITRE DE LA THESE

Surrogate-based optimization of hydrofoil shapes using RANS simulations

Résumé

This thesis presents a practical hydrodynamic optimization framework for hydrofoil shape design. Automated simulation-based optimization of hydrofoil is a challenging process. It may involve conflicting optimization objectives, but also impose a trade-off between the cost of numerical simulations and the limited budgets available for ship design.

The optimization framework is based on sequential sampling and surrogate modeling. Gaussian Process Regression (GPR) is used to build a predictive model based on data issued from fluid simulations of selected hydrofoil geometries. The GPR model is then combined with other criteria into an acquisition function that is evaluated over the design space, to define new query points that are added to the data set in order to improve the model. A custom acquisition function is developed, based on GPR variance and cross validation of the data. A hydrofoil geometric modeler is also developed to automatically create the hydrofoil shapes based on the parameters determined by the optimizer. To complete the optimization loop, FINE/Marine, a RANS flow solver, is embedded into the framework to perform the fluid simulations.

Optimization capabilities are tested on analytical test cases. The results show that the custom function is more robust than other existing acquisition functions when tested on difficult functions. The entire optimization framework iss then tested on 2D hydrofoil sections and 3D hydrofoil optimization cases with free surface. In both cases, the optimization process performs well, resulting in optimized hydrofoil shapes and confirming the results obtained from the analytical test cases. However, the optimum is shown to be sensitive to operating conditions.

Mots-clés : Surrogate-based optimization, Gaussian process regression, RANS simulations, geometric modeling, hydrofoils, ship design

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