Incorporating Deep Bagging Ensemble Method as a Surrogate Model for Simulating Hyper-Concentrated Sediment-Laden Flows

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Macroscale and mesoscale simulations of hyper-concentrated sediment-laden flows rely on robust couplings of the Reynolds-Averaged Navier-Stokes equations in conjunction with the shear-stress transport k-ω turbulence model. Also other closure laws for modeling the momentum transfer between the fluid and dispersed particles phase are applied. A numerical framework is developed to couple and solve the various algebraic and Partial Differential Equations (PDEs) based on the Euler-Euler method. A 3D high-fidelity simulation of sediment transport based on two-phase modeling approaches (i.e., Euler-Lagrange and Euler-Euler models) can be computationally prohibitive. A deep bagging ensemble method based on Regression Tree and Model Tree approaches is incorporated into the coupling procedure of the ten PDEs involved in the problem to improve computational efficiency. The performance of the surrogate model was also compared with two traditional surrogate models, i.e., Artificial Neural Network and Kriging meta-modeling. The CFD and surrogate-based models were validated for horizontal transport of cuttings created during an offshore drilling process. In particular, during the hole cleaning procedure, it was challenging to simulate the two-phase flow of the cuttings and non-Newtonian drilling fluid due to the complex interactions between fluid-particle, particle-particle, and particle-wall. Therefore, a four way coupling method was utilized to consider the interdependency of motions between two phases. The values of sediment and fluid concentrations, the velocities of both phases, and pressure loss estimated by the surrogate models were compared with the results of CFD simulations and experimental investigations. The results indicate that the proposed hybrid CFD-surrogate model is capable of providing physical insights into the dynamics of cutting transport, and the resulting computational observations are in line with the relevant CFD simulations and experimental investigations.

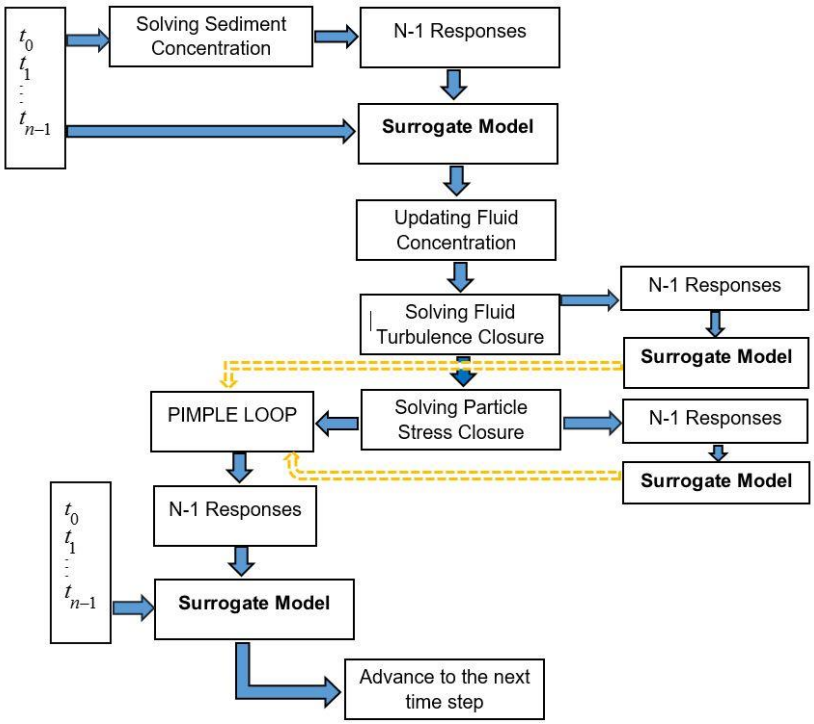

Figure 1. General procedure of coupling and developing the surrogate model.

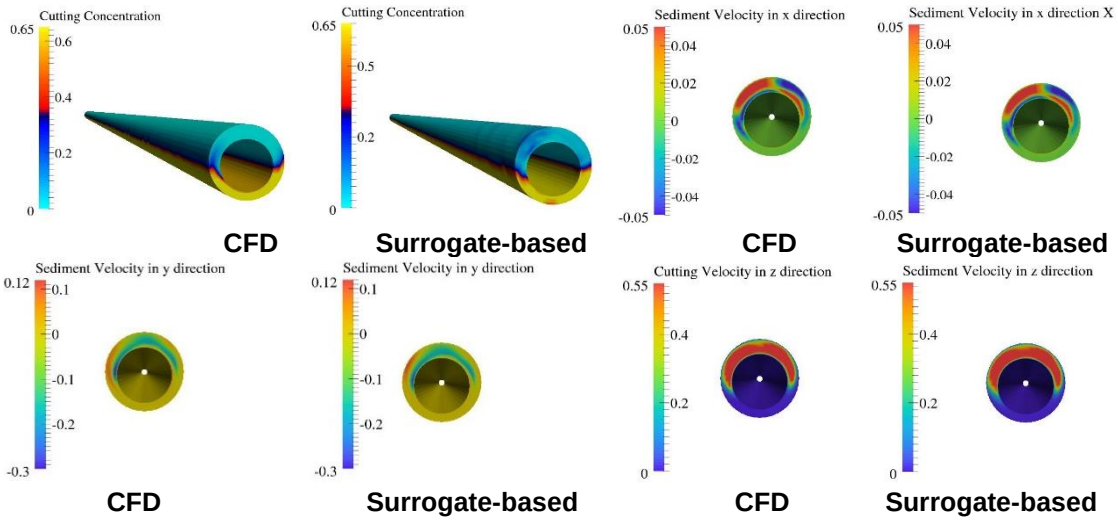

Figure 2. Comparisons between results of CFD and surrogate-based model.

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