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Optimal design of tree location for fluid flow power reduction

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To reduce the power of fluid passing through a tide-water control forest plays important role in the field of the tsunami hazard mitigation. Although there are some research concerning the effect of trees in terms of fluid resistance as represented by the coefficient of drag, those attempts have not yet led to an effective tree arrangement which should be defined by quantitative understanding of the flow field.

In this study, we develop a simulation system by combining an optimizer based on the genetic algorithm and the Lattice Boltzmann simulator working on a Graphics Processing Unit (GPU).

We performed two types of simulations:

(1) Find the optimal arrangement of trees which minimize the integrated kinetic energy over the wake flow produced by trees.

(2) Find the optimal arrangement of trees which maximize the integrated viscous dissipative energy over the wake flow produced by trees.

As a result, the first design concept leads to a trivial solution which places trees only on the edges of the simulation model. In contrast, the optimal arrangement of trees obtained from the 2nd design concept indicates about quintuple score as compared to the average of randomly placed tree arrangement, suggesting that we should consider the capability of flow control regulated by the tree arrangement.

The evolution process from the initial stage to the optimal tree arrangement, the consequence from the genetic algorithm, clearly derives a knowledge relating to the viscous dissipative energy involved in the vortex formation.

Keywords: tree, fluid, optimization, genetic algorithm, LBM, GPGPU