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Large-Scale Finite Element Simulation and Modeling for Environmental Flows

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A number of natural disasters occur annually in various parts of the world. Especially, a number of natural disasters in cities increases in accordance with the development of city area, such as flood, wind disaster and air pollution. In order to estimate the extent of a disaster quantitatively, it is necessary to estimate the behavior of natural phenomena which causes the natural disaster. In practical computations of this type of problems, the computational domain is large and the computations need to be carried out over long time durations. Therefore, this type of problem becomes quite large-scale and it is essential to use methods which are as efficient and fast as the available hardware allows.

In recent years, massively parallel finite element computations have been successfully applied to several large-scale simulations for natural phenomena. These computations demonstrated the availability of a new level of computational capability to solve practical problems. However, in order to compute natural phenomena accurately, it is necessary to prepare an accurate shape model for landform, buildings and civil structures. Furthermore, a good-quality finite element mesh must be prepared for the complicated spatial analytical domain.

In this presentation, a large-scale computer modeling and simulation method is presented for environmental flows in urban area. Several GIS and CAD data were used for the preparation of shape model and an automatic mesh generation method based on Delaunay method was developed. Parallel finite element method based on domain decomposition method was employed for the numerical simulation of natural phenomena. The present method was applied to the simulation of flood flow and wind flow in urban area. The shallow water equation and the Navier-Stokes equation were employed for the governing equations. The stabilized finite element formulation based on SUPG/PSPG was employed for the discretization in space. The present method is shown to be a useful tool for the prediction of natural disasters and the change of environments.

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