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Top -level research and data

Research on new methods of fluid analysis involving solid contact, and elucidation of its phenomena

(Representative papers)
Multiscale space–time fluid–structure interaction techniques. Takizawa, K. et al., *Computational Mechanics*, 2011, 48, pp.247–225

Keyword

- Fluid analysis
- Structural analysis
- Fluid-structure interaction analysis
- Isogeometric analysis

Deployment targets (sites, materials, etc.)

Automobiles, wind turbines, spacecraft parachutes, cardiovascular systems, etc.

Features (implementation means, etc.)

Simulation of “fluid-structure interaction problems” involving fluids, solids (structures), and their interactions on computers by researching discretization methods from the modeling of each component. To achieve precise modeling, while keeping in mind the reproduction of each complex phenomenon, the multi-scale nature in which these phenomena co-exist at various scales is focused on, and research is conducted from both physical and mathematical aspects. Realization of analyses that were impossible until now, with representative examples including parachute descent with large deformations, detailed flow analysis near heart valves that open and close, and flow analysis around the contact surfaces of tires and road surfaces.

・Megawatt-class wind turbines can reach up to 100 meters in diameter. The flow created by such wind turbines (wake vortex) is extremely strong and propagates to the rear. In clustered wind turbines, depending on the arrangement of the wind turbines, it is known that not only does it become difficult to efficiently capture wind energy but also that the vibration of the blades due to strong vortex-containing flows flowing into the wind turbine shortens the life of the wind turbine. Knowing more about the wake of a wind turbine is important for understanding these aspects in detail. The flow chart shown in Fig. 1 is an aerial visualization of the wake created when the atmospheric boundary layer flow created by temperature and Coriolis force flows through a wind turbine. It can be seen here how the rings merge as the strong ring-shaped vortices propagate hundreds of meters downstream. In the present study, a new method is proposed that uses periodicity to reduce computational costs by over 85% for computations with the same resolution.

Figure 1: Efficient analysis of the wake of a wind turbine

・When reproducing something with a spatial gradient dependence, such as a fluid, on a computer, if the topology of the space changes, then the expression of the spatial gradient changes discontinuously, making it difficult to perform highly accurate analysis. To date, reproduction has been performed at the expense of either simply expressing the dynamics of the vicinity or approximately expressing the topological change itself. The present study reproduces, without any compromise, the topological change of a tire rotating while coming into contact with a road surface such as that in Fig. 2, and it captures the boundary layer flow near the tire.

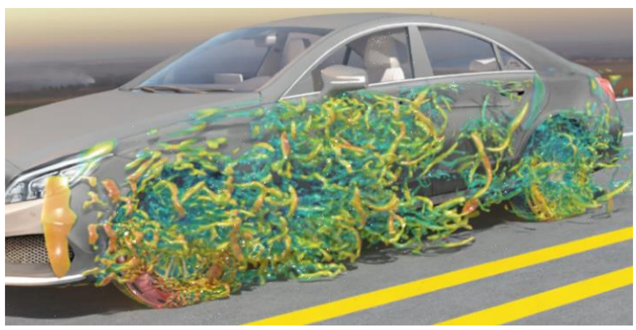

Figure 2: Fluid analysis, including contact with the road surface

Associated proprietary technologies

・Numerical analysis technology using supercomputers for computer-aided engineering
・Space–time isogeometric analysis method, particularly for analyzing moving boundary problems where the boundary between the fluid and solid moves
・Modeling technology based on continuum mechanics, which is the foundation of mechanical engineering

Assumed outlets / applications

Multi-scenario phenomenon prediction technology that aims to predict a new future without data

Associated SDGs

3 GOOD HEALTH AND WELL-BEING
7 AFFORDABLE AND CLEAN ENERGY
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION