15th World Congress on Computational Mechanics (WCCM-XV)
8th Asian Pacific Congress on Computational Mechanics (APCOM-VIII)
31 July – 5 August 2022, Yokohama, Japan

Three-Dimensional Super-Resolution of Passive-Scalar and Velocity Distributions Using Neural Networks for Real-Time Prediction of Urban Micrometeorology

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Key Words: *Building-Resolving Micrometeorological Simulations, Three-Dimensional Super-Resolution, Neural Networks, Real-Time Prediction*

In future cities, various IoT devices such as drones will constantly access meteorological data and social network information on cloud networks. Each system using IoT devices will provide a variety of services in response to complex changes in weather and society without people being aware of it. Such social services will require real-time predictions for urban micrometeorology.

Our research group has developed a micrometeorological model that can resolve buildings and tree canopies at several meter resolution in urban areas (e.g., [1]). However, the computational cost of such simulations is high, and the real-time prediction is difficult even with a supercomputer. We have recently proposed a “super-resolution simulation method” [2] using deep learning, where high-resolution inferences are obtained with a neural network from the low-resolution results of micrometeorological simulations. Once the neural network is trained, it can make inferences at low computational cost, which would make the real-time prediction possible.

Our previous study [2] demonstrated the feasibility of super-resolution simulations for two-dimensional temperature, whereas the information of three-dimensional wind velocity is essential for flying IoT devices such as drones. Although there have been studies on super-resolution of three-dimensional velocity with neural networks (e.g., [3]), these studies discussed canonical flows such as channel turbulence and the effectiveness of three-dimensional super-resolution for complex real-world flows has not been confirmed. This research proposes a neural network super-resolving both passive-scalar and three-dimensional velocity and applies it to building-resolving micrometeorological simulations in urban cities. We discuss the generalization performance of the neural network and the feasibility of the real-time prediction using it.

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