# Developments in Wind Turbine Wake Modeling based on Machine Learning

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This study provides a development of a new wind turbine(wake) modelling method based on machine learning for precise wind prediction by numerical simulation. (wake: Area where the wind speed generated on the downstream side of the wind turbine is low, and the airflow is complicated and turbulent.) Evaluation of site-specific wind conditions is required in wind power since turbulence is cause of wind turbine failure, although wind is source of energy. In a large-scale wind farm consisting of multiple wind turbine groups, the interaction of "wake" between wind turbines causes a decrease in the total power generation and an increase in the risk of failure. Therefore, in the wind power generation business, it is important to select the optimal installation site taking into account the effects of wakes, the optimal design of the wind turbine layout, and the operation of the power plant with minimal risk of failure.

Wind simulation has been utilized in the design and operation of wind farms. These simulations enable highly accurate prediction of power generation and evaluation of the risk of wind turbine failure by precisely reproducing the reduction in wind speed and wind turbulence caused by wakes, together with meteorological and oceanographic characteristics and topographic turbulence. In the field of wind simulation, a number of physical models (wake models) have been proposed and validated to reproduce wakes with high accuracy. Uchida et al. [1] succeeded in developing a CFD porous disk model, which simulates a part of a wind turbine rotor with a resistive element, and demonstrated its effectiveness by comparing it with actual measured data of wind farms in coastal areas. In recent years, however, expectations for new modeling methods based on machine learning have been rising. Machine learning has the potential to accurately model complex nonlinear phenomena that are difficult to formulate, such as wakes. In this study, we constructed and verified the accuracy of a new wake model using machine learning, which is different from the conventional fluid dynamics viewpoint, in order to realize a wake model with high robustness and versatility that does not require complicated parameter adjustments. For the supervisory data of the machine learning model, we used wind tunnel tests, LiDAR measurements for coastal wind turbines, and time series data during the inflow wind speed and wake region from the CFD analysis (without modeling the wake). These measurements and analyses produce a variety of wind data sets at different wind turbine outputs (blade lengths) and wind conditions.

## REFERENCES

[1] Uchida, T., Taniyama, Y., Fukatani, Y., Nakano, M., Bai, Zhiren., Yoshida, T., and Inui, M. A New wind turbine CFD modelling method based on a porus disk approach for practical wind farm design. *Energies*. (2020) **13**.