The 2020 World Congress on
Advances in Civil, Environmental, & Materials Research (ACEM20)
25-28, August, 2020, GECE, Seoul, Korea

Prediction of wake effect in wind farm using machine learning

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ABSTRACT

A novel framework that employs the machine learning approach to replace the conventional CFD (computational fluid dynamics) simulation is developed to capture the wake characteristics of a wind farm consisting of multiple turbines, which strikes good balance of accuracy and efficiency. An ANN (artificial neural network) model based on the back-propagation (BP) algorithm is proposed to build the relationship between inflow wind speed, blade pitch angle and the velocity field of turbine wake. ADM-R (actuator disk model with rotation) is incorporated into RANS simulations to provide big wake velocity data for training, testing, and validation. The ANN framework is deployed on the wake characterization of a standalone NREL PHASE VI wind turbine and driven by the 843 groups of training data and 48 groups of testing data. The architecture of ANN is composed of 1320 sub-models, each of which contains 10 neurons with single hidden layer and produces a streamwise velocity vector. The inflow wind speed and the blade pitch angle are selected as input variables and the non-dimensional wake velocity is taken as output variable. The wake field of an aligned row of 8 turbines is obtained by sum-of-square superposition of wake deficits caused by the individual upstream turbines. The ANN-based superposed predictions show good agreement with the CFD results, indicating that the powerful capability of ANNs model in establishing the complex relationship between inflow speed, blade pitch angle and the wake velocity field.

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