Comparing artificial neural network models with statistical methods for estimating low-occurrence wind speed at pedestrian levels of simplified arrays

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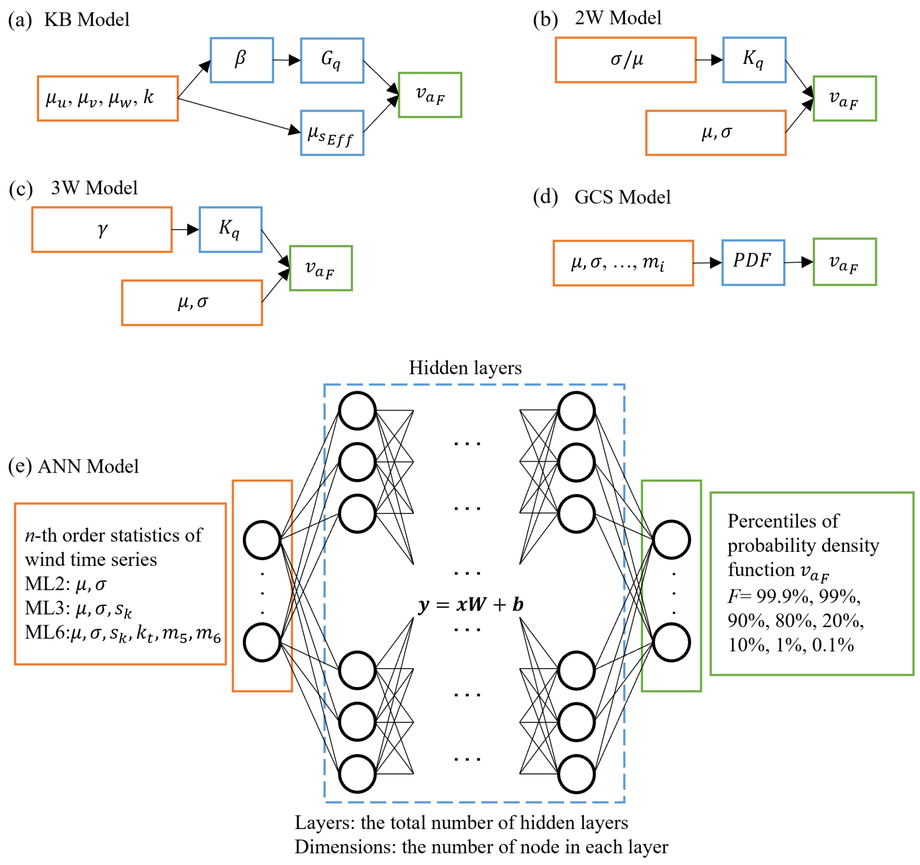
Introduction

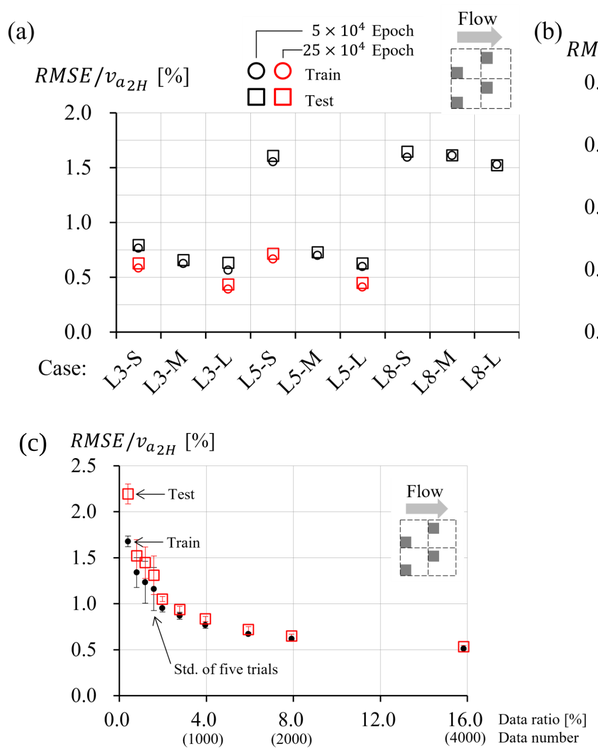
Low-occurrence wind speed in urban areas has a profound impact on the daily activities of people. Although several statistical methods were developed for estimating the low-occurrence wind speeds, their accuracy and flexibility still need improvements. In this study, artificial neural network (ANN) models were designed to estimate the low-occurrence wind speeds based on the moments. After the sensitivity tests for the dimensions, hidden layers, epochs and training data ratios of the ANN models, the optimal setting was applied to predict the low-occurrence wind speeds of two building array cases. The applicability of the ANN models was also evaluated for the extrapolation method between two building array cases and compared with the traditional statistical methods.

Methods



The optimization of the ANN training process is based on the stochastic gradient descent method by a 100 mini-batch data randomly selected from the entire training data. The learning rate is 0.1. The gradients of the parameters at each layer are calculated based on the backward propagation method.

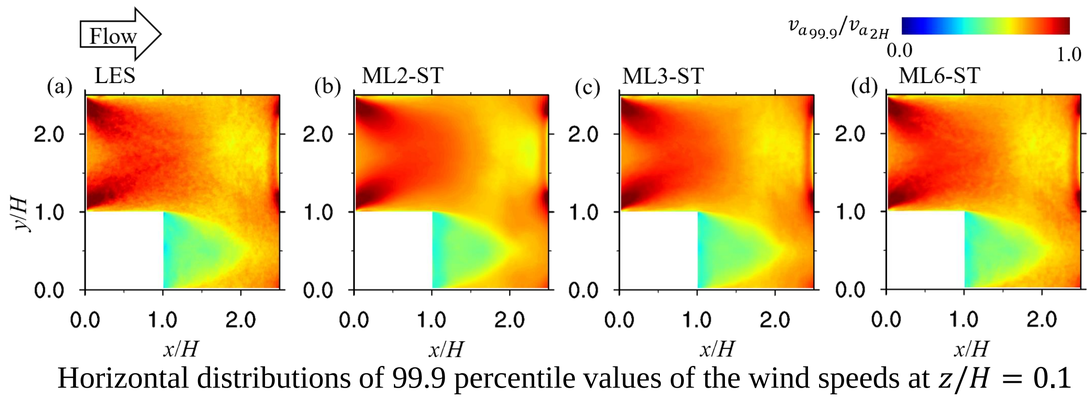
Sensitivity test of hyperparameters



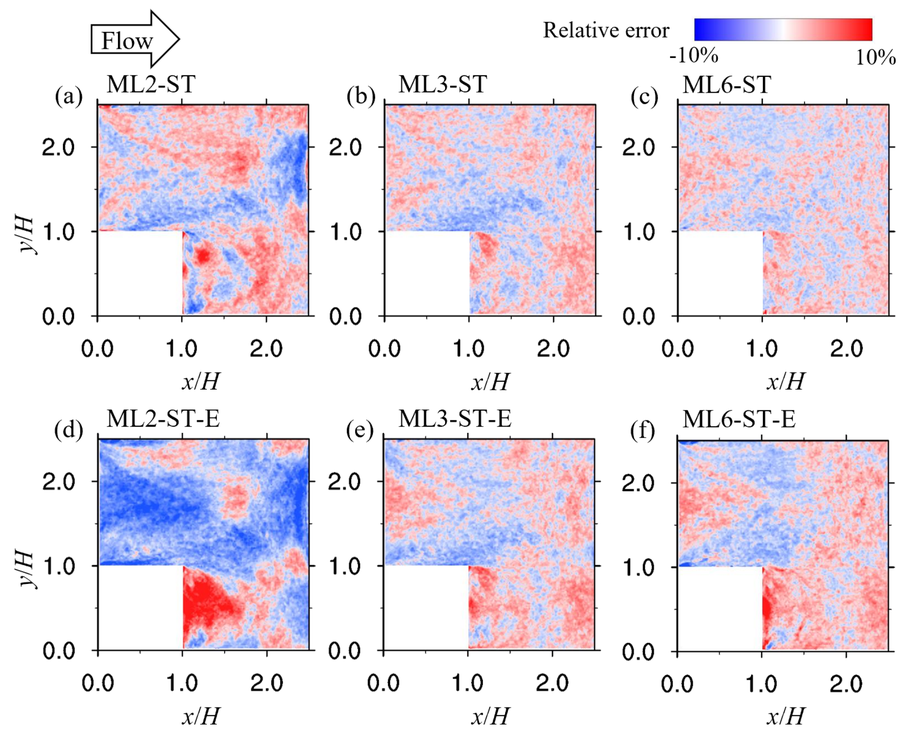
ANN model sensitivity tests for determining the hyper parameters of the dimensions, layers, and epochs

Optimal setting:
L5-L
100000 epochs
2000 data number

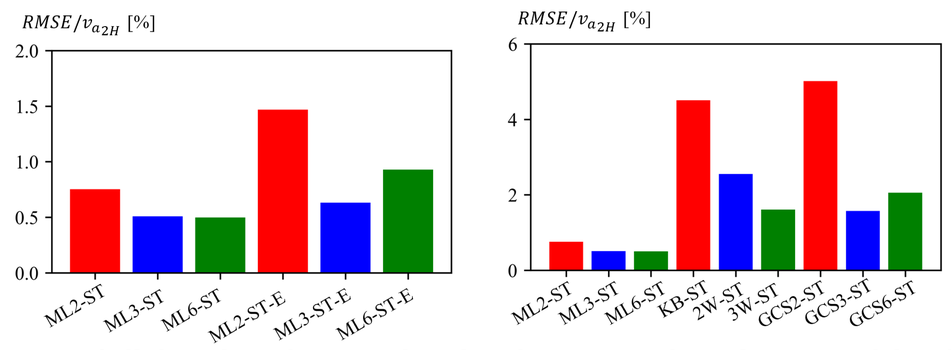
Results and Discussion



Horizontal distributions of 99.9 percentile values of the wind speeds at $z/H = 0.1$



Distributions of relative errors for 99.9 percentile values of the wind speeds at $z/H = 0.1$



RMSE of all the selected percentile values between each prediction model and LES

Conclusion

The ANN models with the second-, third- and sixth-order statistics input well reproduced the low-occurrence wind speeds for the staggered building array case. The results obtained from the interpolation method are more accurate than those calculated from the extrapolation method. For the extrapolation method, the adaptability of the model could be enhanced by using input data of an order higher than the second. The ANN model is more efficient and accurate to predict the percentile values of wind speeds than the traditional statistical methods.

Reference

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