Convolutional Neural Network Architectures for Wind Analysis

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Abstract

In today's world, with increasing demands of green energy resources, wind energy is one of the freely available natural options, as a replacement for nonrenewable sources of energy. The past nature of the wind speed and direction affects the behavior of future wind patterns. Further, selecting a location to install new wind sensors and turbines requires pre-assessments of the wind nature, *i.e.*, to have a brighter clear picture of highly influencing factors of wind speed and direction. This work proposes a One-dimensional (1D) Single Convolutional Neural Network (1DSCNN) for the temporal wind dataset in order to predict dominant wind speed and direction in the future. The proposed 1DSCNN has an input layer, three convolutional layers, two fully connected layers, and an output layer. Moreover, the proposed design of 1D Multiple CNN (1DMCNN) integrates several 1DSCNN but with different views of the same input, therefore, learning more information compared to the 1DSCNN. This 1DMCNN architecture has five single CNN, and each of these CNN has its own input layer, as in the 1DSCNN and connects to the two common fully connected layers followed by the softmax layer. These advanced deep learning architectures are trained and tested on multiple samples made using temporal wind datasets. A sample has input values and a corresponding output class (*i.e.*, dominant speed or direction). Input values comprise of consecutive temporal values in terms of the wind speed and direction. For designing the output class of the sample, first, μ and σ of complete wind dataset are calculated, that are then used to define eleven boundary conditions (or classes), separately for speed and direction. Amongst the successive values in the dataset, after the last value in the sample's input, count of the values occurring in these eleven classes are calculated. The class with the maximum count, *i.e.*, dominant, is assigned to the sample's output. The proposed architectures are then trained using the input and output of these samples. After the training, the methods are tested using several testing samples for predicting the output class, *i.e.*, dominant wind speed, and direction in the future. The training and testing of the proposed architectures are done using the historical wind datasets of Stuttgart (Germany) and Netherlands for different months. The obtained total accuracies reach up to 95.2%, 95.1%, for predicting the dominant wind speed and direction, respectively, using the 1DSCNN and up to 98.8%, 99.7% for predicting the dominant wind speed and direction, respectively, using the 1DMCNN. The 1DSCNN and 1DMCNN as classification methods, work on the original 1D wind data values with self-learning features and future time frame of prediction depends on the user. The other existing methods use regression techniques, smoothed wind data, and manually designed features for predicting speed and direction. Therefore, the proposed work would be thoughtful and supportive for installation of wind sensors, and turbines whose power output depends on the above parameters.

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