World Academy of Science, Engineering and Technology
International Journal of Environmental and Ecological Engineering
Vol:18, No:10, 2024

Developing a DNN Model for the Production of Biogas From a Hybrid BO-TPE System in an Anaerobic Wastewater Treatment Plant

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Abstract : Deep neural networks are highly regarded for their accuracy in predicting intricate fermentation processes. Their ability to learn from a large amount of datasets through artificial intelligence makes them particularly effective models. The primary obstacle in improving the performance of these models is to carefully choose the suitable hyperparameters, including the neural network architecture (number of hidden layers and hidden units), activation function, optimizer, learning rate, and other relevant factors. This study predicts biogas production from real wastewater treatment plant data using a sophisticated approach: hybrid Bayesian optimization with a tree-structured Parzen estimator (BO-TPE) for an optimised deep neural network (DNN) model. The plant utilizes an Upflow Anaerobic Sludge Blanket (UASB) digester that treats industrial wastewater from soft drinks and breweries. The digester has a working volume of 1574 m3 and a total volume of 1914 m3. Its internal diameter and height were 19 and 7.14 m, respectively. The data preprocessing was conducted with meticulous attention to preserving data quality while avoiding data reduction. Three normalization techniques were applied to the pre-processed data (MinMaxScaler, RobustScaler and StandardScaler) and compared with the Non-Normalized data. The RobustScaler approach has strong predictive ability for estimating the volume of biogas produced. The highest predicted biogas volume was 2236.105 Nm^3/d, with coefficient of determination (R2), mean absolute error (MAE), and root mean square error (RMSE) values of 0.712, 164.610, and 223.429, respectively.

Keywords : anaerobic digestion, biogas production, deep neural network, hybrid bo-tpe, hyperparameters tuning
Conference Title : ICW 2024 : International Conference on Wastewater
Conference Location : Tunis, Tunisia
Conference Dates : October 24-25, 2024