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Advanced hybrid neural network techniques for minimizing gas turbine emissions

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Purpose

Emissions have significant environmental impacts. Hence, minimizing emissions is essential. This study aims to use a hybrid neural network model to predict carbon monoxide (CO) and nitrogen oxide (NOx) emissions from gas turbines (GTs) to enhance emission prediction for GTs in predictive emissions monitoring systems (PEMS).

Design/methodology/approach

The hybrid model architecture combines convolutional neural networks (CNN) and bidirectional long-short-term memory (Bi-LSTM) networks called CNN-BiLSTM with modified extrinsic attention regression. Over five years, data from a GT power plant was uploaded to Google Colab, split into training and testing sets (80:20), and evaluated using test matrices. The model's performance was benchmarked against state-of-the-art emissions prediction methodologies.

Findings

The model showed promising results for GT CO and NOx emissions. CO predictions had a slight underestimation bias of −0.01, with root mean-squared error (RMSE) of 0.064, mean absolute error (MAE) of 0.04 and R^2 of 0.82. NOx predictions had an RMSE of 0.051, MAE of 0.036, R^2 of 0.887 and a slight overestimation bias of +0.01.

Research limitations/implications

While the model demonstrates relative accuracy in CO emission predictions, there is potential for further improvement in future research.

Practical implications

Implementing the model in real-time PEMS and establishing a continuous feedback loop will ensure accuracy in real-world applications, enhance GT functioning and reduce emissions, fuel consumption and running costs.

Social implications

Accurate GT emissions predictions support stricter emission standards, promote sustainable development goals and ensure a healthier societal environment.

Originality/value

This paper presents a novel approach that integrates CNN and Bi-LSTM networks. It considers both spatial and temporal data to mitigate previous prediction shortcomings.

Previous

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Gas turbine emission; Nitrogen oxide; Carbon monoxide; Predictive emissions monitoring systems; Statistical data analysis; CNN-BiLSTM

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1 The 2015 Climate Change Framework Convention. Source: http://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf [accessed June 05th, 2024].

2 Carbon Tax Center [CTC]. Website: http://www.carbontax.org/[accessed July 23rd, 2023].

3 1990 Clean Air Act Amendment Summary: https://www.epa.gov/clean-air-act-overview/1990-clean-air-act-amendment-summary [accessed Aug 15th, 2023].

4 GT CO and NOx emission Data Set (2019). UCI machine learning repository. Link to the article.