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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 (NO_x) 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 NO_x 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. NO_x 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.



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