Deep Transformers for Analysing Industrial Steelmaking Data

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Abstract

This study investigates the application of advanced deep learning models, specifically transformer-based architectures, to model the basic oxygen furnace (BOF) steelmaking process, with a focus on accurately predicting endpoint temperature. Achieving precise temperature predictions is critical for optimizing process parameters, enhancing product quality, and ensuring energy efficiency in BOF operations.

This work represents the first extensive deployment of such models on BOF operational data. We rigorously evaluated five state-of-the-art deep learning models using a comprehensive dataset consisting of over 10,000 samples from a large-scale industrial setting. Among these models, we introduced a novel architecture, TTB-BOFNet, tailored to handle the complexities of industrial-scale BOF data. TTB-BOFNet leverages transformer models enhanced through exploratory data analysis-informed binning to better interpret intricate interactions and generate contextual embeddings. Our novel architecture demonstrated a notable improvement in predictive performance, achieving a 4.65% increase in the R-squared value compared to the multi-layer perceptron (MLP) benchmark and a 1.79% improvement over the Tab Transformer model. Additionally, Shapley Additive explanations (SHAP) analysis was employed to interpret the TTB-BOF Net model predictions, revealing the effectiveness of both the EDA-informed binning approach and the model's transformer-based structure in capturing critical features and improving predictive accuracy. These findings underscore the potential of transformer-based deep learning models to optimize industrial processes through advanced, data-driven approaches, paving the way for significant advancements in industrial process modelling.