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融合自注意力机制和 CONV-LSTM 的核电厂跨工况时序预测方法研究

摘要

随着全球能源需求的不断增长和环保要求的日益提高，核电作为一种绿色、清洁的能源形式，日益受到关注，核电厂在全球能源结构中的地位逐渐重要。然而，核电厂的复杂性及其对安全性的高度要求，使得其运行面临着诸多挑战，尤其是在时序数据的预测和监控方面。针对这一问题，本文提出了一种基于深度学习的核电厂跨工况时序预测方法。该方法结合了卷积神经网络（CNN）、长短期记忆网络（LSTM）和自注意力机制（Attention），能够有效处理核电厂不同工况下的时序数据。数据来源于 AP1000 核电厂的 PCTRAN 仿真数据。通过数据预处理和特征提取技术，本文构建了一个高效的时序预测模型，能够在核电厂运行过程中对多种工况下的时序数据进行高精度预测，从而为核电厂的安全运行提供重要支持。实验结果表明，该方法在处理复杂的时序数据时具有较高的预测精度，并能够应对核电厂运行过程中多变的非线性和时变特性。

关键词

跨工况时序预测；核电厂；深度学习；集成学习；长期预测

Abstract

As global energy demand continues to grow and environmental requirements become increasingly stringent, nuclear energy, as a green and clean energy source, has gained significant attention, with nuclear power plants playing an increasingly important role in the global energy structure. However, the complexity of nuclear power plants and their high safety requirements pose numerous challenges in their operation, particularly in the prediction and monitoring of time-series data. To address this issue, this paper proposes a deep learning-based method for cross-condition time-series prediction in nuclear power plants. This method integrates Convolutional Neural Networks (CNN), Long Short-Term Memory Networks (LSTM), and Attention mechanisms, enabling effective processing of time-series data under various operating conditions of nuclear power plants. The data used in this study comes from the PCTRAN simulation data of the AP1000 nuclear power plant. Through data preprocessing and feature extraction techniques, an efficient time-series prediction model is constructed, capable of providing high-precision predictions for time-series data under multiple conditions during the operation of nuclear power plants, thereby offering important support for their safe operation. Experimental results demonstrate that this method achieves high prediction accuracy when handling complex time-series data and is capable of addressing the nonlinear and time-varying characteristics encountered in nuclear plant operations.

Keywords

Cross-condition time-series prediction; nuclear power plant; deep learning; ensemble learning; long-term prediction

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