Transformer-Based approach for Solar Energy Forecasting

Proposal

Introduction

The increasing reliance on solar power as a sustainable energy source has underscored the importance of accurate solar energy forecasting. Such forecasting plays a crucial role in various aspects of energy management, from enhancing grid reliability to optimising energy storage solutions. Recent advancements in deep learning have led to the exploration of transformer-based models, known for their efficacy in capturing complex dependencies within sequential data. This proposal aims to extend the current state-of-the-art by employing transformer-based approaches to not only maintain high accuracy in short-term forecasting but also to bridge the gap in medium- to long-term solar energy forecasting.

Research Problem

The current research shows promising advancements in short-term solar energy forecasting, with studies employing deep learning models like CT-NET for enhanced precision using convolutional transformer-based networks [1]. Hybrid CNN-LSTM-Transformer frameworks have also been effective in minimising forecast errors [2]. Despite these strides, a gap persists in medium-to-long-term forecasting [1], crucial for comprehensive energy management. Moreover, the literature suggests that while models such as the Temporal Fusion Transformer offer precise day-ahead predictions [3], the broader application of these models for energy production forecasting, especially paired with energy storage systems, remains relatively uncharted [2]. Additionally, models focusing on solar irradiance [4] stop short of translating these forecasts into actual energy output. This research proposes to bridge these gaps, targeting long-range forecasting and exploring the integration of predictive models with better accuracy.

Research Objectives

- Enhanced Forecasting Accuracy and Forecasting period: Achieve a significant improvement in solar energy forecasting accuracy and forecasting period over existing methodologies, especially in scenarios with high variability.
- Robustness Across Conditions: Ensure the model's resilience and reliability across diverse weather conditions, seasons, and times of day.
- Operational Efficiency: Demonstrate the model's capability to support optimal energy storage, grid management, and the integration of renewable resources.
- Contribution to Sustainable Energy Transition: Highlight model's potential impact in fostering a smoother transition towards a more renewable-centric energy paradigm.

Proposed Method

The research will commence with the acquisition of comprehensive datasets detailing solar energy production, concurrent weather conditions, and other potentially influential variables. The proposed transformer-based model will be carefully designed and trained to interpret the nuanced relationships within the data relevant to solar energy production.

The model's architecture will be refined through iterative enhancement, including hyperparameter tuning and extensive validation. It will be benchmarked against current models and assessed for its performance in various forecasting ranges. The development will be followed by a thorough evaluation of its effectiveness in operational contexts. The study will culminate in a comprehensive analysis of the model's contribution to the solar energy sector, emphasising its practical application for grid management and energy planning.

References

[1] Munsif, M., Ullah, M., Fath, U., Khan, S. U., Khan, N., & Baik, S. W. (2023). CT-NET: A Novel Convolutional Transformer-Based Network for Short-Term Solar Energy Forecasting Using Climatic Information. Computer Systems Science & Engineering, 47(2).
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