MODERN TECHNIQUES FOR SMART HOME LOAD PREDICTION: FROM ARIMA TO DEEP LEARNING

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Accurate residential energy forecasting is becoming increasingly critical as smart grid infrastructures evolve and distributed energy resources (DERs) like rooftop solar, home batteries, and electric vehicles become more widespread. This study offers a comparative analysis of traditional statistical models and modern machine learning (ML) techniques for short-term electricity demand forecasting in residential settings. The complexity and variability of household energy consumption, influenced by human behavior and environmental factors, require models that go beyond linear assumptions to capture dynamic and nonlinear usage patterns.

The thesis evaluates the performance, adaptability, scalability, and deployment feasibility of statistical models such as ARIMA and exponential smoothing alongside deep learning architectures like Long Short-Term Memory (LSTM), CNN-LSTM, and Transformer-based networks. Results indicate that ML models significantly outperform traditional approaches in environments with high data variability, providing improved prediction accuracy, adaptability to concept drift, and scalability across multiple households. For instance, deep learning techniques demonstrated superior performance in capturing load variations related to occupancy, appliance scheduling, and renewable generation, as shown in studies by [1] and Fekri et al. [2].

However, the advantages of ML models are counterbalanced by their higher computational demands and dependence on large, high-quality datasets. In contrast, classical statistical models remain relevant in scenarios characterized by predictable consumption patterns and limited computational resources, making them ideal for on-device deployment and microcontroller-based systems. The study also discusses emerging solutions such as federated learning and model compression techniques, which aim to address privacy and performance constraints by enabling decentralized training and lightweight inference [3].

This research highlights the need for hybrid, scalable, and interpretable forecasting models that integrate predictive accuracy, privacy awareness, and real-time adaptability. As smart homes become more data-centric, future energy forecasting systems must not only be accurate but also robust, secure, and seamlessly integrated into intelligent control frameworks.

References:

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