Smart Grid Big Data Analytics for Identifying Residential Power Consumption Patterns to Optimize Electricity Usage based on a Web-based Energy-Saving Decision Support System

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Abstract

The building sector is a major energy consumer, accounting for approximately 40% of the global energy consumption and 30% of CO2 emissions, and its share of energy consumption is increasing because of urbanization. Improving building energy efficiency is imperative for reducing energy costs and environment impacts. Currently, big data analytics and cloud computing are emerging practices for sustainable energy systems and efficient energy management. This study developed a smart decision support system (SDSS) for smart grid data analytics for increasing energy savings in buildings. A hybrid nature-inspired metaheuristic machine learning-based forecast system and a dynamic optimization algorithm are developed for achieving accurate prediction and optimization of future energy consumption. End users can reduce their electricity costs by implementing optimal operating schedules for appliances, which are provided by the SDSS.

Research Results

(1) An Innovative Framework

In this study, a framework for a smart grid big data analytics system was developed as Fig. 1. The framework can efficiently retrieve, analyze real-time electricity consumption data, predict future energy consumption, and provide optimal operation schedules for appliances. The framework was verified by installing a smart grid metering infrastructure in a residential building. The proposed framework was expected to serve as a basis for the future development of a full-scale smart decision support system (SDSS)

(2) Time Series Analytics System

This study proposed a novel sliding window metaheuristic optimization-based prediction system (SARIMA-MetaFA-LSSVR) to analyze time-series data generated from a smart grid for efficiently forecasting energy consumption 1 day in advance. The proposed prediction system integrates metaheuristic firefly algorithm-based least squares support vector regression (MetaFA-LSSVR) model with a seasonal autoregressive integrated moving average (SARIMA) model and can compensate for the limitations of the SARIMA model.

(3) Evalution Results for Prediction System

The proposed SARMIA-MetaFA-LSSVR system yielded high accuracy and reliability in 1-day-ahead predictions of building energy consumption as shown in Fig.2. In particular, the system obtained average R, RMSE, MAE, MAPE, MaxAE, and TER values of 0.799, 0.161 kWh, 0.026 kWh, 14.785%, 0.185 kWh, and 2.742%, respectively.

Comparison results revealed that the proposed prediction system is superior to the linear forecasting method (i.e., SARIMA) and nonlinear forecasting methods (i.e., LSSVR and MetaFA-LSSVR), proving the merit of combining linear and nonlinear models for analyzing time-series energy consumption data. Notably, the system exhibited improved performance measures in the range of 36.8–113.2% compared with the other models.

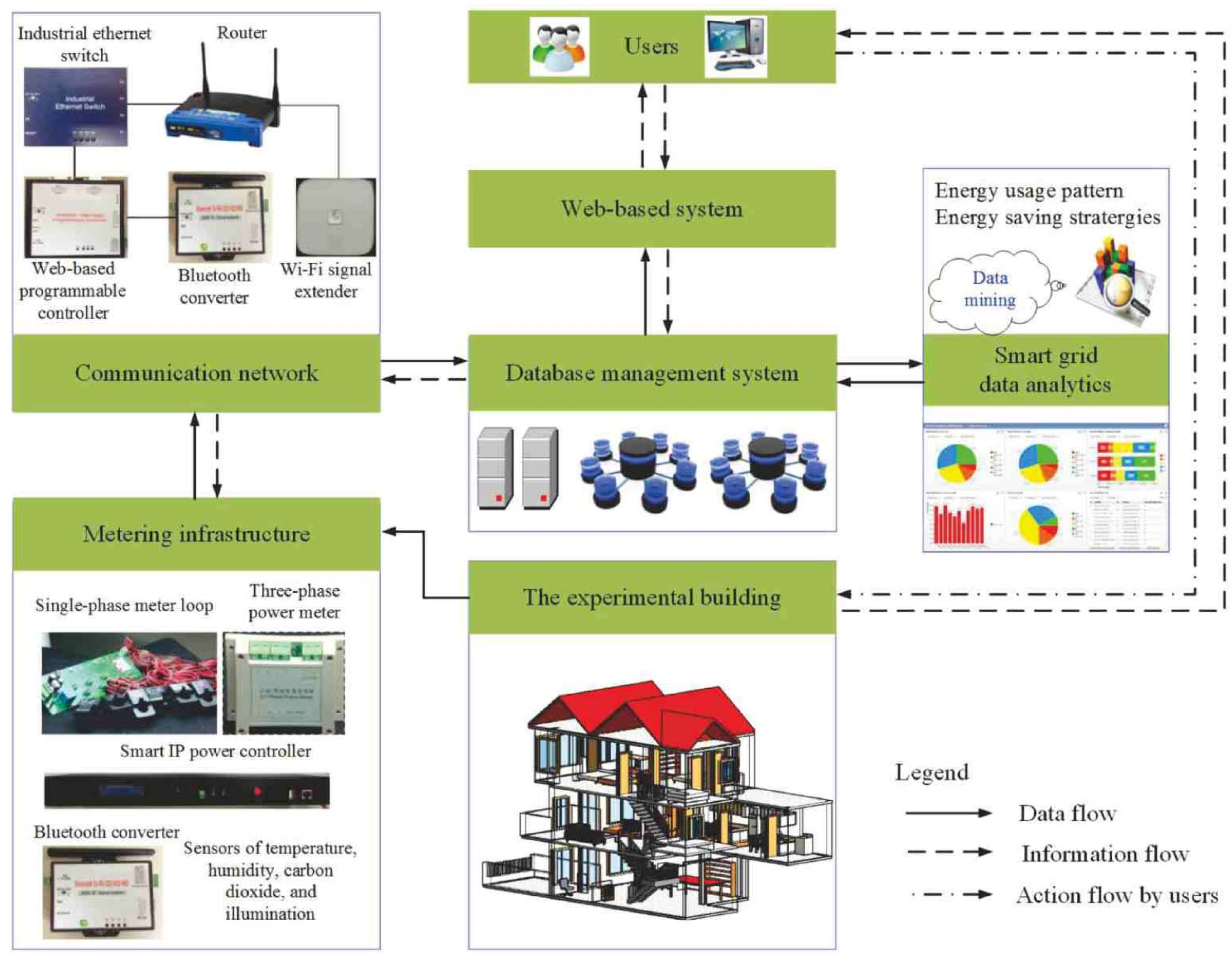

Fig. 1. A framework of smart grid data analytics for building energy consumption.

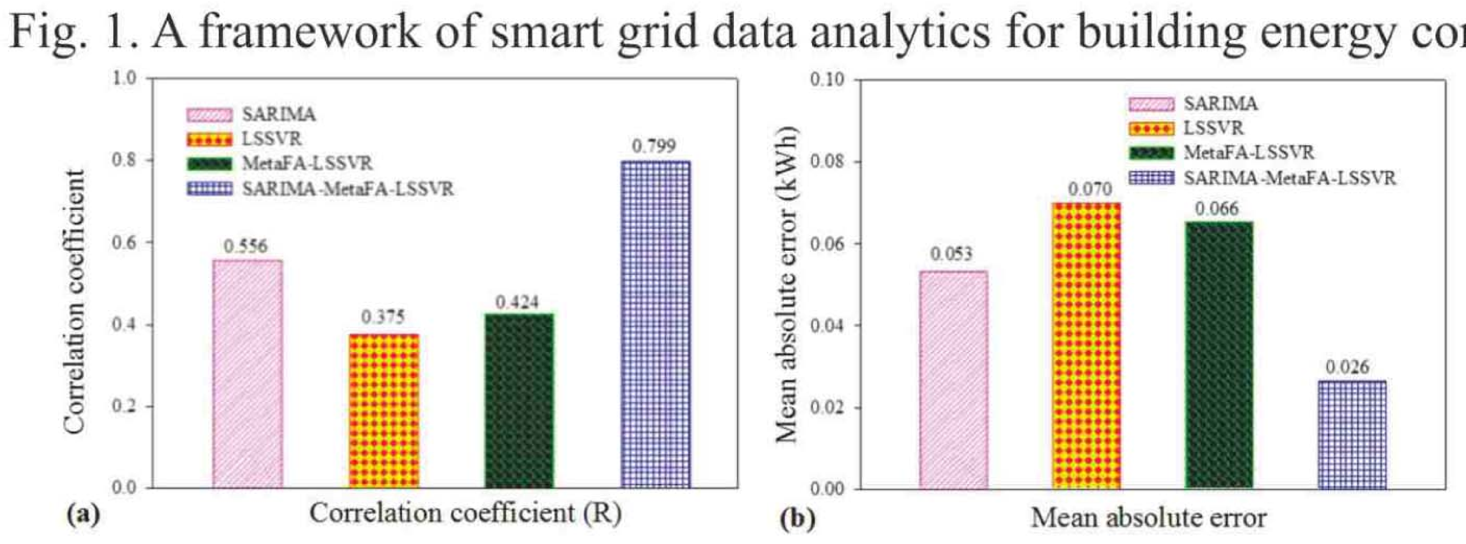

Fig. 2. Performance comparisons.

Research Interests

My research interests are building energy-saving system, proactive project management, data mining in civil engineering and infrastructure, sustainable urban development, and smart city system.