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Forecasting Short-term Electricity Demand in Residential Sector Based on Support Vector Regression and Fuzzy-rough Feature Selection with Particle Swarm Optimization

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Abstract

The aim of this study is to provide a precise model for one-month-ahead forecast of electricity demand in residential sector. In this study, a total of 20 influential variables are taken into account including monthly electricity consumption, 14 weather variables, and 5 social variables. Based on support vector regression and fuzzy-rough feature selection with particle swarm optimization algorithms, the proposed method established a model with variables that relate to the forecast without ignoring some of these variables one may inevitably lead to forecasting errors. The proposed forecasting model was validated using historical data from South Korea. Its time period was from January 1991 to December 2012. The first 240 months were used for training and the remaining 24 for testing. The performance was evaluated using MAPE, MAE, RMSE, MBE, and UPA values. Furthermore, it was compared with that obtained from the artificial neural network, auto-regressive integrated moving average, multiple linear regression models, and the methods proposed in the previous studies, and found superior for every performance measure considered in this study. The proposed method has an advantage over the previous methods because it automatically determines appropriate and necessary variables for a reliable forecast. It is expected that the proposed model can contribute to more accurate forecasting of short-term electricity demand in residential sector. The ability to accurately forecast short-term electricity demand can assist power system operators and market participants in ensuring sustainable electricity planning decisions and secure electricity supply to the consumers.

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1. Introduction

Short-term electricity demand forecasting plays a significant role in power system planning, including economic scheduling of generating capacity and scheduling of fuel purchases, and power system management [1–8]. It is especially obvious that accurate electricity forecasting has great importance to the residential sector, a major contributor to the peak loads in most electricity systems. Overestimating electricity demands misleads planners and wastes resources with expensive expansion plans. Such overestimation also increases operating costs, since electricity cannot be stored on a large scale unlike other energy sources [9,10]. But underestimation of electricity demands will result in failures and shortages [3]. Nevertheless, short-term electricity demand forecasting in the residential sector is a complex problem because its rise and fluctuation is caused by the difference in demand from month to month. In addition, the consumption is influenced by many nonlinear variables, such as weather conditions, economics, and demographics [11–14,3,15,7].

Several research studies have been conducted over the last decades to explore this complex problem of monthly electricity demand forecasting by means of multivariate time series analysis [16–32,7,33–35]. Several studies have assumed that the input and output series are stationary and applied statistical models [16,36,17,21–23,25,30,7]. However, real monthly electricity demand series as well as variables that may influence the electricity demand series have found to be non-stationary characteristic [17]. When one or more of the input and output series are have non-stationary characteristic, it is necessary to consider the sophisticated models which are capable of describing the nonlinear input and output series. In order to solve nonlinear time series problems, most research studies applied auto-regressive integrated moving average model [17,20] and artificial neural network model-based approaches [18,19,24,26,28,29,31–34]. The accuracy of the resulting models has ranged from 1.42% [34] to 10.98% [18] in terms of mean absolute percentage error. However, it is difficult to say whether these models have been sufficiently validated because the evaluation periods of the most research studies were within about ten years [18–20,29,31–34]. In addition, most of the previous studies have assumed that certain inputs among various weather variables and social variables have impact on the electricity demand series and fed these inputs to develop their models. Although some of selected variables may inevitably lead to forecasting errors, to our knowledge, there have been no research studies examining the method that can determine appropriate and necessary variables for a reliable forecast of monthly electricity demand in residential sector.

The aim of this study is to provide a precise model for one-month-ahead forecast of electricity demand in residential sector. Based on support vector regression and fuzzy-rough feature selection with particle swarm optimization algorithms, the proposed method automatically develops a forecasting model with variables that relate to the electricity demand series without ignoring some of these variables one may inevitably lead to forecasting errors. To evaluate the forecasting performance of the proposed method, we performed a comprehensive comparison of the prediction performance of the proposed method versus that of the artificial neural network, auto-regressive integrated moving average, multiple linear regression models, and the methods proposed in the previous studies. A data set covers the period from January 1991 to December 2012 was collected from South Korea and used for training and testing experiments. In Section 2, we present some materials on the proposed methodology. In Section 3, we described the data set and pre-processing. In Section 4, we present a discussion and analysis of the experimental results. Section 5 contains conclusions and suggestions for future research.

2. Methodology

2.1. Analysis steps

This study was conducted according to the procedure outlined in Fig. 1. In Step 1, support vector regression (SVR) and fuzzy-rough feature selection with particle swarm optimization (PSO) algorithms were applied to select the most relevant variables from the 19 input variables. As a result, the number of multi-dimensional input variables was reduced. In Step 2, a forecasting model was developed by training the support vector regression model with the variables selected in the first step. In Step 3, the artificial neural network (ANN), auto-regressive integrated moving average (ARIMA), multiple linear regression (MLR) models, and the methods proposed in the previous studies were trained. In Step 4, the forecasting performance of the ten models was compared.

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