International Journal of Gaming and Computer-Mediated Simulations
Volume 16 • Issue 1

Residential Electricity Consumption Prediction Method Based on Deep Learning and Federated Learning Under Cloud Edge Collaboration Architecture

Wei Wang, State Grid Hebei Marketing Service Center, China
Xiaotian Wang, State Grid Hebei Marketing Service Center, China
Xiaotian Ma, State Grid Hebei Marketing Service Center, China*
https://orcid.org/0009-0001-1419-2141
Ruifeng Zhao, State Grid Hebei Marketing Service Center, China
Heng Yang, Beijing Tsingsoft Technology Co., Ltd., Beijing, China

ABSTRACT

Traditional residential electricity prediction methods have problems, such as difficulty in ensuring user privacy and poor convergence speed due to the influence of Different Residential Electricity Consumption (REC) habits. A REC prediction method based on Deep Learning (D-L) and Fed-L under the Cloud Edge Collaboration (CEC) architecture is proposed to address the above issues. First, based on the CEC architecture, combining edge computing and cloud computing center server, the overall model of REC prediction is built. Then, Federated Learning (Fed-L) and D-L model Empirical Mode Decomposition - Long Short-Term Memory (EMD-LSTM) were introduced on the edge side, and the edge side Fed-L depth model was personalized by using EMD-LSTM. Finally, aggregation of edge side models was achieved in the cloud by receiving encrypted model parameters from the edge side and updating and optimizing all edge side models. The results show that the proposed method has the highest REC prediction accuracy, reaching 96.56%, and its performance is superior to the other three comparative algorithms.

KEYWORDS

Cloud Edge Collaboration, Federated Learning, EMD, LSTM, Residential Electricity Consumption Prediction, Simulation

DOI: 10.4018/IJGCMS.336846

*Corresponding Author

1. INTRODUCTION

The reliability and economy of power system operation are important guarantees for the healthy development of both society and the economy. Before a significant breakthrough in energy storage technology, the electricity generation and consumption are roughly equal (Hong et al., 2020; Wang et al., 2022; Chodakowska et al., 2021). Therefore, the planning and operation of the power system, as well as the daily scheduling work of the power system, require REC prediction as the decision-making basis, which has important research significance (Rendon-Sanchez & De Menezes, 2022).

With the continuous development of new energy grids, the combination of new energy and REC has become increasingly close. REC prediction has higher value, higher difficulty, and new technological foundation in the new era. When the power grid consumes intermittent, random, and fluctuating new energy generation, it needs to have a certain reserve capacity. However, when the grid's capacity is insufficient, serious waste of resources, such as wind and solar power, may occur (Phyo & Jeenanunta, 2021; Barman & Dev Choudhury, 2022; Tran et al., 2021). With the further development of electricity market reform, the number of users in the electricity market is gradually increasing. The power market adopts the market mechanism to improve the efficiency of various users in the power sector. Accurate and reliable REC prediction is an important basis for the business decisions of users, such as power companies and retailers. Therefore, as the number of market participants increases, the number of stakeholders who need to make decisions based on REC predictions gradually increases (Li et al., 2022; Mustaqeem & Kwon, 2022). In addition, with the further opening of the electricity market, the impact of REC's predictive power on the profitability of relevant power companies and retailers is gradually increasing. Therefore, REC prediction has a more important position in the new market environment (Ahmed et al., 2020; Huang et al., 2021; Basiri et al., 2021). Moreover, the accuracy of REC prediction results will directly affect the quality of urban power grid planning work (Shahid, Zameer, Muneeb et al., 2021; Wang et al., 2020; Kong et al., 2019). Due to the complex and diverse factors that affect the prediction of residential electricity REC, simply considering the characteristics of the energy consumption system itself is completely insufficient in the energy Internet mode. On the basis of in-depth analysis of electrical characteristics, taking into account social, meteorological, economic, and other influencing factors is necessary to ensure the accuracy and stability of prediction accuracy (Chen et al., 2022; Sheng et al., 2021).

In addition, accurate REC prediction can ensure better trading in the dynamic electricity trading market and is also an important indicator for future planning of the power system. Accurately providing predicted load data for the corresponding period plays a crucial role in generating and selling electricity, formulating reasonable electricity prices, and ensuring the normal production and life of residents. However, the level of REC is influenced by local economic development level, human activities, REC characteristics, and climate conditions, which undoubtedly increase the difficulty of predicting electricity REC (Bento et al., 2021; Gao et al., 2022).

At present, scholars have conducted more research on precise load prediction algorithms for total household electricity demand, but there has not been in-depth research on precise interaction of terminal devices based on residential demand response, multidimensional evaluation models, interaction strategies under multiple factors, identification and simulation of key loads for residents, and other related contents. This cannot provide effective scientific research or theoretical support for the construction of residential energy Internet (Alfieri & De Falco, 2020; Xie et al., 2020; Shahapure & Nicholas, 2020). Due to the lack of data resources for the REC situation and the integration with key data in the substation area, both the depth and breadth of research and the support for practical applications need to be strengthened. It is far from meeting the application requirements to support the interaction between the power grid and the residential intelligent REC, nor can it support the full mode simulation of the source network load storage under the large power grid. Therefore, based on accurate REC prediction research, it can quickly make up for the current shortcomings and provide good theoretical support for residential intelligent REC, which is of great significance in ensuring