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Diagnosing Electricity Stealing Behavior Based on Deep Learning Algorithm in E-learning Context: Research and Application

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Abstract. To diagnose and analyze the electricity-stealing behavior of the deep learning algorithm to study and apply the diagnosis and analysis method of the algorithm, it is statistically significant to compare the overall effect, comprehensive performance evaluation, coupling degree, and relevant factors of the electricity-stealing behavior diagnosis by the traditional exclusion method and the intelligent deep learning algorithm. The deep learning algorithm can better study and apply the analysis of electricity theft, more accurately diagnose the specific data of electricity theft, find that the running time and the size of data are basically linear, reduce resource consumption, and further improve the analysis, research, and application of electricity theft diagnosis.

Keywords: stealing electricity; Learning algorithm; Traditional exclusion method; Linear relationship; Resource consumption; E-Learning Context
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1 INTRODUCTION

With the progress of the times and the continuous development of the economy, the electricity consumption of all walks of life is increasing, and the electricity is not enough to limit power. At the same time, electricity theft is also a severe problem. This behavior affects not only the economic interests of the State Grid but also the order in which electricity is consumed. In this regard, Shen Jiayi (2022) proposed using deep learning to calculate the relationship between abnormal indicators and standard indicators to solve the monitoring of abnormal power consumption to diagnose and analyze the result of electricity theft [4]. Wan Quan (2022) developed a behavior analysis and identification method based on the low efficiency of the current rural power grid investigation of electricity theft. It uses statistical analysis to quantify the essential characteristics of electricity consumption behavior, screen out the suspect group, and identify the suspected target by using the variation index and peak detection [6]. Xia Xuezhi (2022) studied the anti-electricity theft detection system, the online device detection of intelligent locks and multidimensional probes, the innovative transformation of meter boxes, the traceability analysis of unpacking operation behavior and

unpacking action to prevent electricity theft, and the identification and authentication of intelligent transformation of meter boxes [8]. Bian Haiyuan (2021) proposed to analyze the abnormal behavior of electricity consumption according to data mining, such as current, voltage shortage, spread, phase shift, etc., divide the data set by similarity, initialize the attribute update, calculate the target, and determine the data type according to the calculation results, to design the screening process of abnormal electricity consumption [1]. Tang Donglai (2018) pointed out that the direction of power grid intelligence and initiative is to monitor and analyze the state of power theft in the direction of informatization to strengthen the prevention and combating of power theft and ensure that the power industry will resist development [1]. Shi Yuliang (2018) proposed to extract sample features by filtering algorithm and setting rules, establish a diagnosis model by logistic regression algorithm, lock it and the target, conduct multiple troubleshooting and processing, and constantly optimize the diagnosis model to verify its feasibility [5]. Liu Yongguang (2022) developed a line loss hierarchical positioning method. A hierarchical calculation model is established based on positioning and the line loss method. The calculation hierarchy is obtained, the high loss range is selected, the error model of the electric meter is designed, and abnormal electric energy is screened within the high loss range to achieve the high loss positioning point [3].ZhangHechuan (2022) studied the anti-electricity theft system. Through the upper acquisition card of the acquisition layer, the metering device uses the original data of the smart meter, transmits the power consumption data of the communication layer to the central station for integration, and uses the learning analysis algorithm to analyze the data to obtain the behavior data analysis results [10]. There are increasingly high-level scientific and technological means and brides stealing electricity, which can't be prevented. Technical means and concealment make stealing electricity more significant and the investigation more difficult. Therefore, this study adopts deep learning algorithms and advanced technologies to severely crack down on this behavior and maintain economic construction and social stability by diagnosing and researching electricity stealing behavior through deep learning algorithms.

2 DIAGNOSES OF ELECTRICITY THEFT

Developing the national economy and improving people's living standards are inseparable from electricity. Still, electricity charges are an indispensable part of the operating costs of most people and enterprises. Enterprises with high electricity consumption will try to reduce the expenses brought by electricity charges and reduce funds. Also, individual employees of power grid operating enterprises will cooperate with customers because of their interests; disregarding such behavior of users and failing to supervise and restrict marketing management will allow these groups to take advantage of loopholes. In addition, the legal publicity related to power is not enough; many users need to realize the seriousness of the problem, and the investigation and punishment efforts are also insufficient. These are the main factors that have led to persistent behavior. Xiang Yitong (2022) pointed out that, at present, the forms of anti-theft are diversified, and the behavior of electricity theft is also changeable; the investigation of violations has become very complex. In this regard, we collect information to manage the data, analyze different models of electricity theft data, select suspected targets, manage them, and standardize the workflow [9]. Wang Lian (2022) proposed to design an automatic detection system for power consumption abnormalities. The system can be divided into a collection processor and a control detector. First, the data is collected and then processed. The controller performs module technology on the data, extracts abnormal data through the initial data analysis, and finally shows the deviant user [7]. At the same time, determining the line loss rate is also an effective method to check this behavior, and the power factor analysis method is mainly aimed at commercial users. The power factor is significant and fluctuates significantly so that the power will stay low because of the sudden drop of the count value, so the change of the power number directly determines whether there is an abnormality. There are also many household users whose electricity consumption patterns differ from most ordinary users, so there must be abnormalities.

3 TRADITIONAL ALGORITHM OF ELECTRICITY STEALING BEHAVIOR DIAGNOSIS

Electricity theft has always puzzled the power supply part. For the investigation of electricity theft, the staff of the power supply office observed the line loss rate and the users' electricity consumption in the area. According to previous industry experience and industry rules, it is determined that the suspected user is looking for the target of electricity theft. The traditional detection method mainly uses metering devices for prevention, lacks real-time monitoring, and the detection effect is insufficient. The electricity consumption mode is generally monthly. To analyze each user's electricity consumption data indicators in the current month and to investigate the suspicion of electricity theft. Electricity theft is usually divided into the time series of electricity consumption, the classification of user information and industry, the line loss of the station area, the abnormal warning of the electricity meter, the imbalance of current and voltage, and the abnormality of the electricity quantity of the electricity meter. These are all the analysis methods. The commonly used algorithm is also measured by the metering device of the transformer supplying power in the station area. The general rule of the amount of electricity obtained by reading the meter every month is the sales amount; secondly, in the power book, there are likely to be irregular fluctuations of individual users within a specific range, and the electricity consumption is lower than 10% in the past, which must be suspected. Such algorithms generally apply to large industrial and commercial users, mostly in low-voltage and non-low-voltage residents. However, they are only sometimes practical in detection. In addition, when checking each household, data algorithms can be used. For this group of users, it is necessary to know the historical load curve and identify whether there is electricity theft by inspecting the power consumption group. It can further confirm whether there is electricity theft through judgment rules, support vector machines, and other methods.

4 DEEP LEARNING ALGORITHM AND METHOD OF ELECTRICITY STEALING BEHAVIOR DIAGNOSIS

With the development of intelligent big data technology, the traditional power grid is slowly turning to intelligence. The power supply department has not entirely popularized smart meters and power consumption collection systems for power users. The ordinary management method of manually checking electricity theft can no longer meet the current form. Liu Yan (2021) proposed an anti-electricity theft system that integrates algorithms and deep learning algorithms, which uses layer-by-layer training algorithm data to process and establish a deep learning algorithm, Normalize the obtained electric energy calculation stealing information, and convert the high latitude data of the information into low latitude data that can be easily identified and calculated, to achieve high recognition rate and good stability [2]. Zheng Jianning (2021) studied the convolutional neural network model to model and analyze the daily electricity data, establish a feature engineering, screen out different common electricity patterns, and then comprehensively analyze the user's information, line damage, and warning data with a two-layer deep network to compare the suspected users of electricity theft shown in the model [11]. According to the previous detection methods for diagnosing electricity theft, they need to be more comprehensive. Drawing on previous experience, combined with deep learning algorithms and business rules, the data collected by smart meters are comprehensively analyzed to find the users of electricity theft. Convolution networks are used for the time series of electricity consumption, and network connections are used for training user information, station line loss, and abnormal warning; using the model to locate the users who steal electricity accurately dramatically improves the efficiency compared with the previous manual detection and offline random touch.

5 SIMULATION VERIFICATION

5.1 Diagnosis and Analysis of Electricity Theft Behavior Under Different Algorithms and Overall

Effect Analysis of Application

With the continuous increase of overall social electricity consumption, the phenomenon of electricity theft by residential users is increasing, and the phenomenon of electricity theft by many industrial and commercial households and private enterprises is growing yearly. Thus, it is more difficult for power workers to diagnose electricity theft. Now, according to different algorithms, the overall comprehensive effect analysis of the diagnosis and application of electricity theft behavior in four aspects of user type, power consumption, distribution area, and surrounding environment is obtained, as shown in Table 1 below:

Grouping	*Subscriber type*	*Electricity consumption situation*	*Distribution area*	*Surrounding environment*
Traditional algorithm	*73.27*	*74.62*	*79.74*	*78.64*
Deep Learning Algorithm	*96.45*	*95.28*	*94.84*	*95.25*
T	*6.226*	*6.463*	*6.286*	*6.369*
P	*0.045*	*0.039*	*0.043*	*0.038*

Table 1: Overall effect analysis of diagnosis analysis and application Of electricity theft behavior under different algorithms (%).

In Table 1, through the overall effect data of the diagnosis and analysis of electricity theft behavior under different algorithms in the above table, it is evident that the diagnosis of electricity theft behavior using the deep learning algorithm can obtain data results more quickly, intuitively and accurately, which is conducive to the rapid development of the power industry, the rational and optimal use of power energy, significantly promoting the spatial maximization of the power industry, and accelerating the balanced and sustainable development of China's comprehensive national strength.

To better compare the overall effect of electricity theft diagnosis under different algorithms, we visualized the data in Table 1 to get Figure 1:

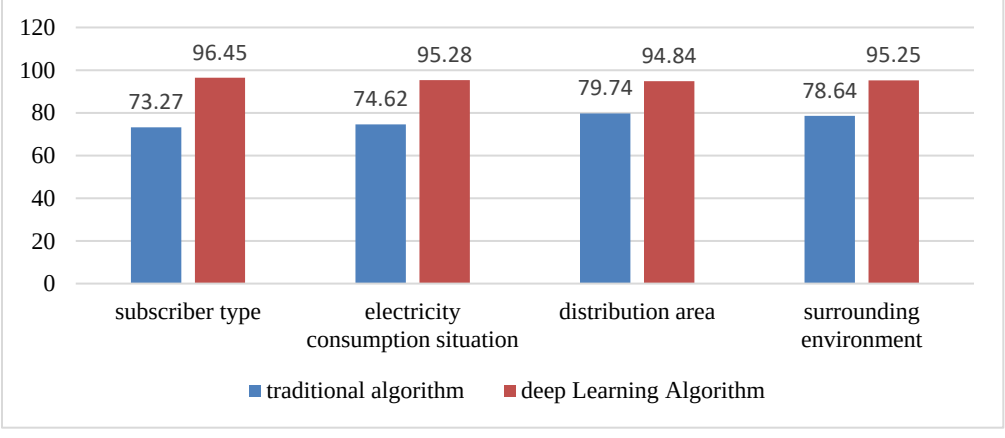

Figure 1: Overall effect visualization of diagnosis, analysis, and application of electricity theft behavior under different algorithms.

Figure 1 shows the overall visualization effect of diagnosing and analyzing electricity theft behavior under different algorithms, clearly showing the massive gap between the deep learning algorithm and the traditional one. The deep learning algorithm can show its overall practical value more intuitively and concretely and more accurately reflect the meticulous results of the data; it can be seen from this that with the progress of the times and the continuous innovation of intelligent technology, the diagnosis of electricity theft in the power industry is fully reflected.

5.2 Comprehensive Performance Analysis of Diagnosis and Application of Electricity Theft Behavior Under Different Algorithms

Diagnosing, analyzing, and applying electricity theft behavior is an indispensable link in the power consumption management of power enterprises. The most important thing to solve the development of the power industry and the rational utilization of power energy is to adopt effective and fast response methods and strategies. Now, according to two different algorithms, the diagnosis of electricity theft behavior is comprehensively analyzed from the aspects of convenience, security, accuracy, and integrity, and the following two are obtained:

Comprehensive analysis	*Traditional algorithm*	*deep Learning Algorithm*
Convenience	*70.32*	*92.26*
Security	*72.23*	*96.45*
Accuracy	*72.62*	*98.36*
Entirety	*70.15*	*95.86*

Table 2: Comprehensive performance analysis of diagnosis analysis and application of electricity theft behavior under different algorithms (%).

Table 2 shows the comprehensive performance data of electricity theft behavior's diagnosis, analysis, and application under different algorithms. These data show that the deep learning algorithm is significantly better than the traditional algorithm, the working method is simple and fast, and the workforce and material consumption are considerably shortened. It has high-security performance and reduces the loss caused by personnel information leakage.

To better evaluate and compare the diagnosis and analysis of electricity theft under different algorithms, we visualized the data in Table 2 and obtained Figure 2:

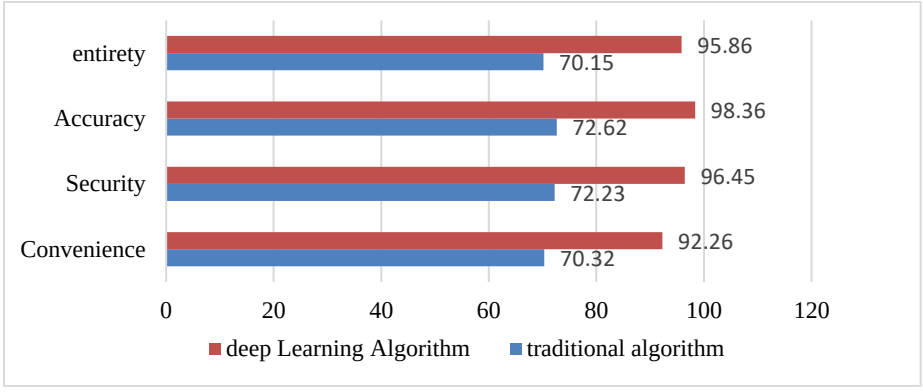

Figure 2: Comprehensive performance visualization of diagnosis analysis and application of electricity theft behavior under different algorithms.

Figure 2 shows the comprehensive performance evaluation visualization of the diagnosis analysis and application of electricity theft behavior under different algorithms. It is intuitive to see that the deep learning algorithm can better and more accurately analyze the diagnosis of electricity theft behavior, effectively reducing the economic loss of the national power industry and thus improving its development scale and prospects.

5.3 Analysis of Coupling Between Diagnosis and Application of Electricity Theft Behavior Under Different Algorithms

In today's society, electric energy plays a vital role in the sustainable development of the national economy and in improving people's living standards. To enhance the efficiency of using electric energy and reduce the loss and consumption of electric power. Now, according to two different algorithms, the coupling degree between the diagnosis analysis and application of electricity theft is analyzed, and the following three are obtained:

Grouping	*Coupling degree*	
	Before use	*After use*
Traditional algorithm	*71.32*	*77.56*
Deep Learning Algorithm	*88.46*	*95.73*
t	*7.396*	*7.028*
p	*0.041*	*0.037*

Table 3: Analysis of coupling degree of diagnosis analysis and application of electricity theft behavior under different algorithms (%).

Table 3 compares the coupling degree data of the traditional algorithm and the deep learning algorithm used in the research and application of the diagnosis and analysis of electricity theft. The coupling degree data of the diagnosis and analysis of electricity theft using the deep learning algorithm is higher than that of the traditional algorithm, and the coupling degree data of the two different algorithms are $T < 10$ and $P < 0.05$, which are statistically significant.

To better compare the coupling degree of diagnosis, analysis, and application of electricity theft behavior under different algorithms, the data in Table 3 is visualized to get Figure 3:

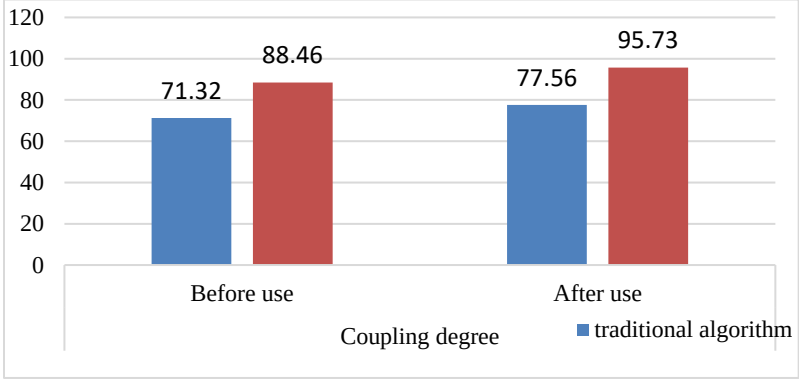

Figure 3: Visual diagram of coupling degree of diagnosis analysis and application of electricity theft behavior under different algorithms.

Figure 3 shows the data visualization of the coupling degree of the diagnosis, analysis, and application of electricity theft behavior under different algorithms. It is very intuitive to see that the coupling degree of the deep learning algorithm in the diagnosis, analysis, and application of electricity theft behavior is better, and the mutual integration effect of the coupling degrees is also better, which is conducive to maximizing the efficiency and interests of the national power industry.

5.4 Comparison and Analysis of Relevant Factors of Different Algorithms in the Diagnosis, Analysis, and Application of Electricity Theft

At present, the overall electricity consumption of society is increasing, which leads to the busy work of power workers, the increased workload, and the increase in time consumption. The economic benefits of power companies are significantly reduced, the consumption of national resources is also growing, and the energy utilization rate is decreasing. The emergence of these situations seriously affects the growth of China's economy. According to the comparison and analysis of the relevant factors in the diagnosis and application of two different algorithms in the diagnosis and analysis of electricity stealing behavior, the following four are obtained :

Grouping	*Work efficiency*	*Economic benefits*	*Energy efficiency*
Traditional algorithm	*70.65*	*76.46*	*78.25*
Deep Learning Algorithm	*90.28*	*94.32*	*92.16*

Table 4: Comparison of relevant factors of different algorithms in diagnosis, analysis, and application of electricity theft.

Table 4 shows the comparative data analysis of the two algorithms regarding work efficiency, economic benefits, and energy utilization. The deep learning algorithm can comprehensively evaluate the use of electric energy, thereby reducing the consumption and diagnosis of electric energy and improving the overall economic benefits of the power industry. Adopting the deep learning algorithm in analyzing, researching, and applying electricity theft diagnosis can save human and material costs and increase national economic efficiency and energy utilization.

To better compare the working efficiency, economic benefits, and energy utilization of different algorithms, the data in Table 4 are visualized to get Figure 4:

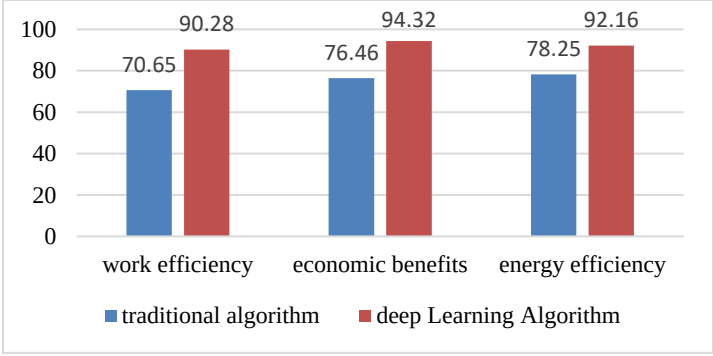

Figure 4: visualization of relevant factors of different algorithms in diagnosis, analysis, and application of electricity theft.

Figure 4 shows the visualization effects of different algorithms on work efficiency, economic benefits, and energy utilization rate. The deep learning algorithm is significantly better than the traditional algorithm in all aspects, which can improve work efficiency, save workforce, material, and financial resources, and increase the utilization rate of energy. Find the most suitable strategy for diagnosing and analyzing electricity theft by continuously optimizing intelligent algorithm technology to promote China's economic construction.

6 SUMMARY

Based on the traditional and deep learning algorithms, this study compares and tests the analysis and application of electricity theft behavior diagnosis, analyzes and studies the data from the overall effect of electricity theft behavior diagnosis, comprehensive performance, coupling data, and relevant factors. Through comparison and statistical methods, it is finally shown that the conclusion of electricity theft behavior diagnosis of deep learning algorithm has a profound impact on all aspects. With the rapid development and popularization of intelligent information technology, the deep learning algorithm can effectively predict the behavior of electricity theft in the power grid by analyzing the data of power grid companies, benchmarking the location of electricity theft users, and narrowing the scope of suspicion; Greatly simplify the diagnosis process, reduce workload, save working time and company cost; Improve the pertinence of the inspection, provide the basis for the investigation of power theft by power supply units, reduce financial losses, and ensure the safety of power grid operation; At the same time, reduce the consumption of national resources and promote the sustainable development of China's economy. Therefore, deep learning algorithms have excellent future application prospects in the power industry. The incorporation of e-learning components plays a pivotal role in prevention. Educational modules and outreach initiatives are designed to inform consumers about the consequences of electricity theft, raise awareness, and empower individuals to make informed decisions regarding their electricity usage.

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REFERENCE

[1] Bian, H.; Liu, X.; Zhang, D.; Shou, J.: Research on abnormal power consumption behavior diagnosis method based on data mining, Electronic Design Engineering, 29 (22), 2021, 139-143

[2] Liu, Y.; Yuan, R.; Zheng, S.; Yang, X.; Wang, Y.: Research on anti-stealing technology of electric energy measurement using DBN deep learning algorithm, Computing Technology and Automation, 40 (04), 2021,151-155

[3] Liu, Y.; Tan, H.; Li, Z.: A-line loss hierarchical positioning method based on the analysis of electric energy meter error and electricity theft, Electrical Measurement and Instrumentation, 59 (09), 2022, 188-194

[4] Shen, J.: Abnormal power consumption monitoring method based on deep learning in AMI environment, Automation, and instrumentation, 2022 (05), 112-116

[5] Shi, Y.; Rong, Y.; Zhu, W.: Electricity theft behavior recognition method based on power consumption feature analysis, Computer Research and Development, 55 (08), 2018,1599-1608

[6] Wan, Q.; Yuan, B.; Liu, H.; Zhang, W.; Chen, Y.; Yan, F.; Zhang, J.; Ou, Y.; Zhou, C.: Research on identification of bypassing and stealing electricity based on analysis of electricity consumption behavior, Power Information, and Communication Technology, 20 (06), 2022,115-121

[7] Wang, L.; Liang, W.: Automatic detection system for abnormal power consumption behavior of power users based on deep mining, Electronic Design Engineering, 30 (16), 2022,112-115

[8] Xia, X.; Gu, M.; Zhang, Y.; Lu, G.; Liu, T.: Research and application of multidimensional online monitoring device in electricity theft prevention, Internet of Things Technology, 12 (06), 2022, 31-33
[9] Xiang, Y.: Research on anti-electricity theft analysis based on collected information data model, Agricultural Power Management, 2022 (07), 37-39
[10] Zhang, H.; Shi, P.; Wang, L.; Shi, H.; Xu, X.: Research on anti-electricity theft system based on multilayer feedforward neural network, Microcomputer Application, 38 (08), 2022, 58-61 + 78
[11] Zheng, J. Electricity theft detection method based on deep learning, Information Technology, 2019 (02), 156-159