Intelligent Analysis of Enterprise Power Trading Based on Stochastic Stability Particle Swarm Optimization

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Abstract: In order to understand the application of particle swarm optimization algorithm in enterprise power trading, research on intelligent analysis of enterprise power trading based on stochastic stability particle swarm optimization has been proposed. The particle swarm algorithm involves three random variables, namely initial position, initial velocity, and learning constant correction coefficient. The distribution function in the algorithm is a uniform distribution. In this paper, the uniform distribution is generalized and transformed into a probability distribution function that meets the corresponding conditions. Based on the 2022 electricity market trading rules of a certain province, formulate a "thermal power conventional" variety purchase strategy in the annual trading. In the case study, uniform distribution and normal distribution were selected as the research objects, and the convergence of the two distributions in the annual strategy formulation of particle swarm optimization was compared. Table 3 shows that selecting a normal distribution (corrected) for only the initial position can significantly improve global convergence.

Keywords: Particle swarm; Electricity trading; Intelligent analysis

1 Introduction

Since its introduction in 1995, Particle Swarm Optimization (PSO) has been widely used for its simplicity, practicality, and fast convergence, especially for solving multivariable optimization problems. However, the local convergence caused by the fast convergence of this algorithm is its most prominent drawback. Scholars have improved the algorithm by introducing contraction factors, time-varying acceleration factors, switching time delays, and other means. Since the release of State Council Document No. 9, the power industry has been guided by Document No. 9 to deepen supply side structural reform and steadily promote the construction of the power market. Due to the increasing pace of society, there are higher requirements for real-time and accurate information. Therefore, the application of information technology and the Internet is increasingly valued in various industries today, as well as in the power industry. With the continuous advancement of China's power industry reform, higher requirements have been put forward for the informatization level of power trading centers. The joint participation of multiple parties in the bidding for electricity sales generates a huge amount of business data. It is necessary to build a cloud platform to assist all parties in conducting diversified data analysis, supporting decision-making, and achieving business linkage application sharing, so as to generate value from scattered business data. With the

PMBDA 2023, December 15-17, Nanjing, People's Republic of China

DOI 10.4108/eai.15-12-2023.2345326

development of power trading center business, the number of market participants, trading varieties, and trading modes in the existing trading system is gradually increasing. The data volume in the system has grown rapidly, resulting in performance issues and poor user experience. Therefore, it is urgent to optimize and transform the existing trading system. The main functions that the power trading platform should include include market management, spot trading, medium and long-term trading, analysis and settlement, and other aspects. Market management: Market subject access, administrator registration, authority maintenance, delisting, agency relationship maintenance, etc. Spot trading: transaction parameter management, unit information maintenance, daily trading declaration, daily trading clearance, daily trading results, real-time trading clearance, real-time trading results, real-time operation information, etc. Medium - and long-term transactions: transaction parameter management, commonly used curve management, electricity limit management, declaration limit management, bilateral market negotiation, market listing management, centralized competitive trading, bilateral base negotiation, centralized base trading, etc. Analysis and settlement: settlement parameter management, daily settlement data preparation, daily settlement calculation, daily settlement result publishing, daily settlement result query, monthly settlement data preparation, monthly settlement calculation, preliminary monthly settlement result publishing, formal monthly settlement result publishing, retail settlement management. This article conducts mathematical modeling research on how to combine the annual and monthly weekly transactions of the conventional thermal power varieties in a certain province's 2022 electricity market, and combines particle swarm optimization algorithm to solve the optimal electricity purchase strategy[1-2].

2 Business Architecture

2.1 Intelligent customer service

The intelligent customer service module can provide fast and efficient customer service to the end users of the trading platform, effectively saving the human resource needs of customer service, and providing unified customer service for different types of platforms through rich interfaces. The design of the intelligent customer service system adopts the most advanced concept at present, focusing on a simple and easy-to-use natural language question and answer format. Combined with the analytical technology capabilities of artificial intelligence, it provides users with a comprehensive service that integrates market trends, information, trading, customer service, chat, etc. With a minimalist interface design, it can achieve almost all the services required by market participants in transactions, truly achieving a one-stop intelligent customer service platform solution. From a business perspective, the architecture design of intelligent customer service includes four business levels: front-end presentation, application services, service engines and content, and data sources.

The intelligent customer service module can be deployed in the system's portal website, mobile app, and WeChat module. In the WeChat module, users can trigger the intelligent customer service function by directly asking questions on the official account, and provide users with relevant services. For questions that robots cannot answer, they can be transferred to the call center and answered by manual customer service.

The intelligent customer service module can intelligently identify the issues raised by users. The user questioning method supports text description, voice description, etc. Intelligent customer service can accurately identify the user's question and provide corresponding solutions. The intelligent customer service module has the ability to self-learning. For problems that cannot be accurately identified, combined with user feedback and guidance from maintenance personnel, the accuracy of problem identification is gradually improved through continuous self-learning. The intelligent customer service module has the ability to expand the knowledge base. For problems where solutions cannot be found from the knowledge base, learning can be completed through manual guidance to achieve iterative updates of the knowledge base[3-4].

2.2 User Behavior Analysis

User behavior analysis is based on data such as electricity trading market operation, power grid operation, market registration, market trading, market settlement, and market member behavior records. It uses big data analysis technology and combines the characteristics of the power industry to conduct user profiling, user behavior analysis, and conduct statistical and in-depth analysis of user behavior.

User behavior analysis has the following characteristics and functions:

(1)Massive data support. Deeply utilize big data technology to achieve PB level big data storage and computation. At the same time, with the help of a distributed data storage architecture, it supports multi copy backup of data, remote disaster recovery, and data is never lost.

(2) Multi source data integration. Support multiple types of data docking methods such as interfaces, files, manual filling, and database incremental synchronization to meet the data docking needs in various scenarios, flexibly adapt to complex and ever-changing data collection standards, and support highly scalable data docking standards.

(3) A mature and reliable evaluation model. Through multiple large-scale cases, a mature KRI risk model has been accumulated, which can model and evaluate risk indices based on different regions, industries, and enterprises. At the same time, it can accurately locate actual risk factors.

2.3 Fund Payment

The existing trading system does not have a fund payment module, and the handling fees and margin are settled through offline payment. The workload of handling fees and margin collection is huge, and it is necessary to expand the fund payment module on the existing trading system. For trading platforms, fund management and settlement are often very complex and important. On the one hand, the existence of multiple transaction modes in trading platforms has led to the diversity and complexity of fund flow, and on the other hand, the platform needs to connect with multiple banks or financial institutions for online payment. If the system cannot provide a unified fund management and settlement plan, it will bring great inconvenience to market entities in the trading process, and also be unfavorable for platform supervision and analysis. It is necessary to establish a unified payment and settlement management plan based on a multi-level account system and accounting processing core, which can access multiple banks (or third-party financial institutions, clearing centers) for unified settlement, and provide centralized fund management services for the platform and market entities[5-6].

3 Case Study on Developing Trading Strategies

3.1 Mathematical Modeling of Trading Strategies

A certain province's electricity sales company has the most participation in the trading of conventional thermal power products. During the operation of the electricity sales company, based on the annual and monthly electricity demand of users, they purchase electricity through annual and monthly weekly trading methods.

Set the total demand to D_0 ($_0d_1$,$_0d_2$,..., $_0d_3$), where 0di represents the total demand for the i-th month, i=1, 2; Purchase electricity D_1=($_1d_1$, $_1d_2$,..., $_1d_{12}$) through annual trading; purchase electricity D_2=($_2d_1$,$_2d_2$...., $_2d_{12}$) through monthly weekly trading. Referring to the standards of the power industry in a certain province, June to September is the wet season; May and October are the normal season; The remaining months are the dry season. Equation (1)

$$D_0 = D_1 + D_2, \text{namely}_0 d_i =_1 d_i +_2 d_i \ (1)$$

3.2 Particle Swarm Optimization Algorithm for Solving Trading Strategies

By combining particle swarm optimization with electricity purchase strategies, a certain amount of electricity demand is reserved for each month in the annual transaction to participate in monthly and weekly trading purchases. This is achieved by using a heuristic algorithm to solve an optimal solution problem of 12 variables. The basic mathematical principles are:

In a 12 dimensional space [0,$_1d_1$] × [$_2d_2$] ×…× In [$_{0m}d_m$], seeking the optimal point d_*^1 so that D(C_*^1) is sufficiently close to min (c) (D1)} is equivalent to equation (2)

$$\frac{\min(cd_i - dc)}{\min(c(D_i))} \quad (2)$$

3.3 Examples of Trading Strategies

Combining the example group algorithm and referring to the modeling of power purchase strategies, an example is now provided. The conventional thermal power electricity consumption of the power selling company is 757817 megawatt hours. Referring to the "water and fire ratio 8:3" trading principle of a certain province's "thermal power conventional", the water and electricity demand is about 533552 megawatt hours (automatic matching of thermal power, referring to the principle of horizontal input and output, not participating in actual transactions). The monthly electricity consumption structure is shown in Table 1. There are currently two ways to purchase electricity in hydropower transactions: annual transactions are purchased through bilateral or platform centralized bidding, and the transaction price is signed based on the industry's high and low price structure formula. The market user quote po=289.00 yuan/megawatt hour. The monthly and weekly trading electricity prices refer to the average monthly transaction prices of the power trading platform of the provincial power trading center in 2022 (specific parameters can be evaluated by each power selling company based on historical data and their own situation). In Table 1, there are no monthly or weekly transactions from January to March. If there is not enough sales in the annual transactions, there will be a deviation assessment. Therefore, it is possible to add a sufficiently large number as its monthly and weekly trading average as a penalty coefficient to ensure that there are no transactions from January to March, as shown in Table 1.

Based on the above requirements and transaction methods, the number of particle swarm is taken as 120, and the number of iterations is set to 1100. The optimal power purchase strategy is shown in Table 2, and the code is shown in Attachment 1. After 12 runs of the code, the calculation results show that the annual optimal average transaction price is 249.76 yuan/megawatt hour. The following combination of trading methods is tentatively considered as the optimal solution for the power trading strategy[7-8].

Table 1 Monthly Structure of Hydropower Part of Power Sales Company

Month	January	February	March	April	May	June	July	August	September	October	November	December	Total
Total annual electricity consumption	48362	38562	40098	46583	46398	46654	46325	48006	47125	28456	46285	48236	531090
Annual trading power	${}_1d_1$	${}_1d_2$	${}_1d_3$	${}_1d_4$	${}_1d_5$	${}_1d_6$	${}_1d_7$	${}_1d_8$	${}_1d_9$	${}_1d_{10}$	${}_1d_{11}$	${}_1d_{12}$	
Monthly and weekly trading power	${}_2d_1$	${}_2d_2$	${}_2d_3$	${}_2d_4$	${}_2d_5$	${}_2d_6$	${}_2d_7$	${}_2d_8$	${}_2d_9$	${}_2d_{10}$	${}_2d_{11}$	${}_2d_{12}$	
Annual transaction price	$f(D_1)$	$f(D_1)$	$f(D_1)$	$f(D_1)$	$f(D_1)$	$f(D_1)$	$f(D_1)$	$f(D_1)$	$f(D_1)$	$f(D_1)$	$f(D_1)$	$f(D_1)$	
Monthly and weekly transaction price	-	-	-	412.30	275.12	176.24	176.45	176.47	176.32	179.24	286.32	393.21	
Monthly and weekly transaction price	998.00	998.00	998.00	412.30	275.12	176.24	176.45	176.47	176.32	179.24	286.32	393.21	

Table 2 Optimal electricity purchasing strategy of power selling companies

Month	January	February	March	April	May	June	July	August	September	October	November	December	Total
Total annual electricity consumption	48536	38456	40068	47563	46895	46253	46023	48005	47521	29362	46231	45326	530239
Annual trading power	47263	38456	40063	29863	0	46352	46231	48632	28952	0	0	0	325812

Monthly and weekly trading power	0	0	0	16674	45036	0	0	0	0	46231	46123	0	154064
Annual transaction price	230.14	230.14	230.14	230.14	230.14	230.14	230.14	230.14	230.14	230.14	230.14	230.14	
Monthly and weekly transaction price	998.00	998.00	998.00	412.32	275.30	176.23	2340.12	176.45	286.32	245.32	286.32	393.45	
Comprehensive electricity price	258.45	258.45	258.45	258.45	258.45	258.45	258.45	258.45	258.45	258.45	258.45	258.45	

3.4 Research on the Generalization of Case Based Distribution Functions

During the convergence process, it was found that the number of iterations is usually 32 to basically complete the convergence, and there are also very few iterations that require 65 to complete the convergence. Therefore, improving the parameters in the experiment and setting 110 iterations can effectively achieve convergence.

In the solving process, the particle swarm optimization algorithm selects three random distributions to compare the uniform distribution and the normal distribution (corrected), namely different distributions:

Each component of the initial position is a random variable, and the values are taken based on the following two distributions:d_iU(0.1) ; , d_i^j =max (min (X ,1),0),where X ~ N(0.5,0.5^2/1.96^2) .

The initial velocity components are random variables, and their values are taken based on the following two distributions: d_iU(—0.16,0.16) ; v_i^j =max (min (x,0.16),— 0.16) ,where X ~N(0,0.16^2/1.97^3).

The correction coefficients x and y for local and global learning constants are determined by referring to the following two distributions: x or y~U (0,1); x or y is max (min (x, 1), 0), where x~N (0.6,0.6 ^ 2/1.97 ^ 2).

In the above power trading decision, the electricity consumption when the purchase cost is less than 260.00 yuan/megawatt is considered as an effective solution, which is global convergence. The experiment combines three random distributions in pairs, with a total of eight sets of calculation results. Each group of algorithms is solved and run 110 times, and the statistical results of effective solutions are shown in Table 3[9-10].

Table 3 Refers to the convergence times corresponding to different distribution functions

Correction coefficient of learning constant	Initial position	Initial velocity	Global convergence times
Evenly distribution	Evenly distribution	Evenly distribution	36
		Normal distribution	32
	Normal distribution	Evenly distribution	38
		Normal distribution	28
Normal distribution	Evenly distribution	Evenly distribution	32
		Normal distribution	32
	Normal distribution	Evenly distribution	46
		Normal distribution	32

4 Conclusion

This article generalizes the random variables in Particle Swarm Optimization (PSO) algorithm and combines them with the trading rules of the 2020 electricity market in a certain province, abstracting the electricity purchase strategy into a mathematical model. The optimal power purchase strategy is obtained by modeling and solving with particle swarm optimization algorithm. Comparing the selection of uniform distribution and normal distribution (correction) for initial position and velocity, as well as learning constant correction coefficients in particle swarm optimization, Table 3 shows that selecting only normal distribution (correction) for initial position can significantly improve global convergence.

References

[1] Lorenzini, G. , Kamarposhti, M. A. , & Solyman, A. A. A. . (2021). A voltage stability-based approach to determining the maximum size of wind farms in power systems. International journal of design & nature and ecodynamics,45(3), 16.

[2] Laghridat, H. , Essadki, A. , & Nasser, T. . (2022). Coordinated control by adrc strategy for a wind farm based on scig considering low voltage ride-through capability. Protection and Control of Modern Power Systems, 7(1), 1-18.

[3] Ding, J. , Chen, Z. , & Du, Y. . (2021). Probability box theory-based uncertain power flow calculation for power system with wind power. International Journal of Emerging Electric Power Systems, 22(2)74.

[4] Kadri, A. , Hasnaoui, O. , Bacha, F. , & Soyed, A. . (2022). Direct power and voltage oriented control strategies of grid-connected wind energy conversion system based on permanent magnet synchronous generator. Cybernetics and Systems, 53(1), 103-125.

[5] Begum, S. R. , & Chandrasekhar, A. . (2023). Opportunities and challenges in power management systems for triboelectric nanogenerators. ACS Applied Electronic Materials, 5(3), 1347-1375.

[6] Maihemuti, S. , Wang, W. , Wang, H. , & Wu, J. . (2021). Voltage security operation region calculation based on improved particle swarm optimization and recursive least square hybrid algorithm. Journal of Modern Power Systems and Clean Energy, 9(1), 138-147.

[7] Dong, W. , & Li, S. . (2021). Reliability sensitivity of wind power system considering correlation of forecast errors based on multivariate nstpnt method. Protection and Control of Modern Power Systems, 6(1)74.

[8] Baldi, F. , Coraddu, A. , Kalikatzarakis, M. , Diana Jeleňová, Collu, M. , & Race, J. , et al. (2022). Optimisation-based system designs for deep offshore wind farms including power to gas technologies. Applied Energy, 3(1)0, 118540-.

[9] Khosravi, M. , Afsharnia, S. , & Farhangi, S. . (2022). Stochastic power management strategy for optimal day-ahead scheduling of wind-hess considering wind power generation and market price uncertainties. International Journal of Electrical Power & Energy Systems, 134, 1(0)7429-.

[10] Su, C. , Liu, C. , Jiang, S. , & Wang, Y. . (2021). Probabilistic power flow for multiple wind farms based on rvm and holomorphic embedding method. International Journal of Electrical Power & Energy Systems, 130(2), 106843.