Soft Computing
https://doi.org/10.1007/s00500-021-06650-z

FOCUS

Meta-heuristic algorithm-based human resource information management system design and development for industrial revolution 5.0

Sixuan Chen[1,2] · Huan Xu[3]

Accepted: 2 December 2021

Abstract

Nowadays, all enterprises have adopted the means of informatization for enterprise management to adapt to the development of society. With the advent of the information age, enterprise transformation has become an inevitable trend. The management efficiency of enterprises is effectively improved, and the optimal scheduling and efficient management of personnel are realized to design and develop a human resource management (HRM) information system to meet the actual needs of enterprises. By studying the current problems of intelligent enterprise system and HRM information system, based on Java programming language, spring model–view–controller (MVC) web application system is combined with browser/server (B/S) framework, and construction is realized on an intelligent enterprise HRM information system. Aiming at the complexity of enterprise HRM, the meta-heuristic algorithm is adopted to optimize the human resource optimization scheduling module. Through the specific example data, the system implementation and model performance comparison experiments are carried out to further verify the effectiveness of the intelligent enterprise HRM information system proposed here. The results show that the HRM information system based on intelligent enterprise system realizes the effective collection and sorting of data, the running system meets the expected research objectives, and different modules can effectively perform specific functions; the algorithm based on meta-heuristic can realize the reasonable scheduling of personnel, and its model performance is significantly higher than the latest algorithm model. With the continuous increase in the number of events, what is improved is the optimal solution ability of the algorithm. Moreover, it decreases with the increase in the number of iterations, converging around 80 times, and the optimization efficiency reaches 86.35%; the system can find the optimal solution in a shorter time under the same number of iterations. Besides, after the system clustering, the accuracy of employee performance reaches 92%. The intellectualization of enterprise HRM greatly improves the office efficiency.

Keywords Intelligent management · Human resources · Information management system · Heuristic algorithm · System structure optimization

Communicated by Deepak kumar Jain.

✉ Huan Xu
xhuan930@126.com

Sixuan Chen
sxchen@njust.edu.cn

[1] School of Economics & Management, Nanjing University of Science and Technology, Nanjing 210094, Jiangsu, China

[2] Jiangsu Institute of Talent Development Strategy, Nanjing 210094, Jiangsu, China

[3] School of Marketing and Logistics Management, Nanjing University of Finance and Economic, Nanjing 210023, Jiangsu, China

1 Introduction

Under the economic globalization and informatization, to adapt to the development of society, all enterprises have adopted the means of informatization for enterprise management, especially with the rapid development of the existing Internet of things, data mining, cloud computing and artificial intelligence technology, which provides a better way for the intelligent management of enterprises (Basheer et al. 2019). With regard to the current information level of Chinese enterprises, many Internet companies and traditional industrial enterprises have adopted information-based methods to achieve efficient management and operation (Jean et al. 2020). However, due to the limitation of enterprise cost, many small- and medium-sized enterprises are unable to develop and design their own management systems, which makes these enterprises face market bottleneck and pressure and even leads to enterprise bankruptcy or elimination (Zhu and Sun 2020). Therefore, the research on intelligent enterprise management system is of great significance to promote the healthy and sustainable development of China's small and medium-sized enterprises and improve social competitiveness (Skobelev et al. 2019). As the core of enterprise operation management, human resource management (HRM) system improves employee contribution and performance by improving internal employee satisfaction and loyalty and helps managers create value chain profits by effectively organizing and managing, reducing costs, and accelerating growth (Chaudhary 2020).

The human resource information management system involves organization planning, recruitment management, personnel on-the-job and resignation files, employee resume, labor contract, reward and punishment management, office supplies, hospital insurance, transfer management, training management, performance management, attendance management, time wage, piece wage, dormitory management, employee self-service, leader approval, etc. To realize each module requires overall coordination, which leads to serious complexity in developing and involving human resources information management system (Tantoh and Simatele 2018). A reasonable HRM system can promote the development of enterprises and increase their core competitiveness. The traditional human resource information relationship system often uses paper and office software to realize recording and preservation. This management method is simple and inefficient, and there is often confusion for personnel management, which seriously hinders the efficient development of enterprises (Papa et al. 2018). The current intelligent enterprise management system ensures efficiency and security to a certain extent through process operation and the way of database and cloud computing. However, in the current intelligent enterprise management system, due to the limitations of system technology, it is faced with great problems in function implementation. Therefore, it is of great practical significance to find the problems of the existing HRM system and optimize the system according to the practical problems (Liu et al. 2021). The traditional human resource information management system has great disadvantages. The meta-heuristic algorithm proposed in this paper is a kind of algorithm that does not rely on the algorithm organization structure information and can realize a wide range of optimal combination. It can effectively deal with complex problems and find the optimal processing method from multiple implementation paths, which is feasible to solve the problem of HRM system (Yang et al. 2020).

Based on the above content, the research firstly takes a company as an example to conduct a full investigation and find the problems existing in the current human resource information management system. Secondly, based on the needs of HRM, the relevant systems are developed, and the intelligent enterprise HRM information system is built by using JAVA programming language, web application system, and B/S framework. Thirdly, aiming at the complexity of enterprise HRM, the meta-heuristic algorithm is used to optimize the human resource optimal scheduling module, and the system is realized. Finally, through the specific example data, the system implementation and model performance comparison experiments are carried out to further verify the effectiveness of the proposed intelligent enterprise HRM information system. The research innovation lies in using meta-heuristic algorithm to optimize the human resource optimization scheduling module for the complexity of enterprise HRM, which can effectively improve the company's HRM level. The results have a certain practical value for the construction of enterprise human resource information management system.

2 Related work

2.1 HRM information system

HRM systems are representatives of information management platforms in the early times, implementing features such as human information entry, simple retrieval, and basic financial processing procedures (Kianto et al. 2017). As technology advances, many scholars have adopted various approaches to improve HRM systems. Qadir and Agrawal (2017) evaluated the current HRM systems from three perspectives. They found that the present management systems could satisfy corporate management demands; however, it cannot bring significant benefits to the enterprises. Hence, improvements to the present management systems were required (Qadir and Agrawal 2017). Kamaludin and Kamil Zaki (2017) adopted the HRM information system to manage their human resource information better. They found that the system could better manage medical workers and improve management efficiency (Kamaludin and Kamaludin 2017). Masum et al. (2018) proposed an intelligent application decision support system and database knowledge intelligent HRM information system framework to improve the HRM decision-making process in a semi-structured and unstructured way. Hybrid intelligent technologies, such as machine learning and data mining, were employed to study how this system solved human resource issues (Masum et al. 2018). Bali

(2019) added modules, such as personnel performance, personnel record management, performance and reward management, corporate communication, and Human Resource Information System (HRIS) satisfaction, to the computer-based HRM information system, which greatly enriched the management system (Bali 2019). Many scholars believe that most underlying codes require technologically advanced frameworks to develop the system. Jawad et al. (2020) pointed out that each research and development (R&D) organization has its R&D framework, such as Spring management framework, Hibernate framework, and Web development framework. Due to the different goals to be achieved by HRMS, combining each different architecture was necessary to implement functions of HRMS in different environments (Jawad 2020).

2.2 Meta-heuristic algorithm management

Usually, heuristic algorithms use a lot of trials and errors to find the best solution in a huge solution space. In contrast, the meta-heuristic algorithm is a trade-off between the global search and the local search. If the algorithm focuses on the local searchability, it will easily fall into the local optimal solution. Compared with the heuristic algorithm, the meta-heuristic algorithm has a wider search range and a stronger ability to find the optimal solution (Zhao et al. 2019). The meta-heuristic algorithm has advantages in solving optimization scheduling problems. Duan et al. (2020) put forward an enhanced meta-heuristic algorithm for network security energy and data, which could apply to the operation and management of smart cities. They found that compared with other meta-heuristic algorithms, this framework significantly reduced the running time and improved the solution accuracy (Duan et al. 2020). Shirvani et al. (2020) proposed a hybrid meta-heuristic algorithm to solve the parallelizable scientific workflow on the elastic cloud platform. For this complex problem, a single method could effectively obtain the optimal solution (Shirvani 2020). Applications of meta-heuristic algorithms in management system design are rarely reported. Li et al. (2021) developed an enterprise HRM evolution strategy based on the core principles of evolutionary methods. They used this strategy to improve HRM efficiency, which converged fast and could jump out of the local optimal value (Li et al. 2021). Bo et al. (2021) designed a rapid response collaborative scheduling model based on online monitoring of cyber-physical production systems to rapidly repair faults in high-speed train wheelset manufacturing. They found that the meta-heuristic algorithm could effectively solve the interruption and rapid response problems in the wheelset production process (Bo et al. 2021).

2.3 Summary of current research progress

The above works reveal that current HRM systems for enterprises in various fields are not unified and perfected, with poor adaptability and pertinence. Many enterprises introduce successful management systems from other enterprises; however, they do not redeploy the business process and basic framework of the enterprise according to these mature systems. Therefore, an HRM system is suitable for enterprises & apos; development should be targeted, and enterprises should develop their HRM systems in this direction. Therefore, the two core functions, namely corporate organization and personnel management, are developed and researched profoundly. Meanwhile, important procedures, such as recruitment and resignation, have been optimized, and the data statistics on personnel have also been expanded further. The meta-heuristic algorithm can effectively deal with HRM problems and is feasible in principle. Therefore, problems in current HRM information systems are analyzed first. Based on the above problems and corresponding system demands, appropriate modules are adopted to build the system. Finally, it is implemented on the corresponding platform.

3 Development of enterprise human resource information management system based on meta-heuristic optimization algorithm

3.1 Survey on information system

In order to further clarify the problems of the current human resource information management system, a large enterprise is taken as the research object and research is conducted in the form of questionnaire and field visit. The questionnaire includes understanding the current situation of HRM at all levels, current personnel organizational structure and strategic layout, influencing factors of HRIS, relevant business processing capabilities and the demand of units at all levels for human resources management information system. The content of the questionnaire mainly refers to relevant literature (Shahreki 2019; Barišić et al. 2019; Wang 2020) and adopts a scientific processing method, where all data are statistically analyzed by SPSS 26.0, and the reliability and validity of the data are analyzed by Student's t-test (Bowden et al. 2018). A total of 250 questionnaires were distributed within the enterprise, and 206 questionnaires were recovered, with an effective recovery rate of 96.35%. The way of field research mainly inquires the main managers of different information management departments.

The reliability of the questionnaire survey results, or, the stability or reliability of the measurement results, refers to the degree to which the results obtained by repeated measurement of the same object with the same method are consistent with the previous measurement results, namely the degree to which the test method is not disturbed by random errors. Validity, or the accuracy and authenticity, refers to the degree to which the measurement tools or means can accurately measure the things to be measured. The Cronbach coefficient is used in the degree analysis. The Cronbach coefficient Cronbach a measured here is $0.8969 > 0.4$, close to 1, indicating that the correlation between the questionnaire data is high and the reliability is high. The validity value Kaiser–Meyer–Olkin (KMO) is $0.8765 > 0.6$, indicating that the questionnaire results are more accurate and reliable.

3.2 System demand analysis

Results of field visits are analyzed, revealing some significant problems in the current HRM information systems. Moreover, different departments have varying requirements for the information system. First, the system must meet the economic feasibility. The purpose is to reduce the expenditure in the HRM process, realizing a paperless office. During analysis, it is necessary to consider various aspects such as requirements, system development, system operation, and system maintenance to reduce investment and development costs. Secondly, it needs to be technically feasible. HRM systems developed by other scholars are analyzed; on this basis, the following development tools are determined: the browser/server (B/S) architecture (Ma et al. 2019), the model–view–controller (MVC) development model, and the Oracle database for data storage (Almeida et al. 2019). Hence, the system needs to have good compatibility. At the technical level, the difficulty is reduced, which is conducive to the development, testing, and later maintenance of the system. Finally, the system needs to be professional and efficient in operation. In daily works, it is necessary to send professional technical personnel for the maintenance work. In the meantime, it is necessary to formulate corresponding emergency plans according to various possible problems and conditions to improve work efficiency (Samsai et al. 2018). The actual working environment and demands of current enterprise managers are understood; afterward, the HRM system is finally divided into 5 modules, namely login management module, organization development module, personnel team management, contract information management, and logistics service guarantee. The detailed functional divisions of the five modules are summarized in Fig. 1.

3.3 System design and development

As per the above demands and corresponding modules, an enterprise HRM information framework is constructed, as shown in Fig. 2. This framework includes four layers. The presentation layer displays the login interface of different user managers; the business logic layer stores and collects different businesses reasonably; the data access layer handles data processing and simple calculations; the database implements the docking and sharing of data between different users (Margatama 2017). This system adopts the B/S architecture. The operator only needs to log in with a browser when the computer is connected to the Internet and follow the prompts to operate.

The login module: users must fill in the usernames and password correctly and check the input information carefully to ensure the consistency of the input. After confirming the submitted information, the system performs the retrieval function, looking for the same information as the input data in the database. Once the information is retrieved, users can log in to the system smoothly. The detailed login steps are summarized in Fig. 3A. Organizational development module: organizational development management deals with the structural relationship between personnel, involving position management, workability efficiency management, and department management. Personnel working in the unit can inquire about their information through the system, such as the affiliation, departmental system status, the network of personnel in which they are located, and the type of work information. The organization management operation is taken as an example in the organization development module, and the flowchart is presented in Fig. 3B. Personnel management module: the human resources department manages the personnel. There are lots of operations to manage the personnel, such as observation period processing, trainee management, formal employment management, leaving and retirement management, and job change management. The flowchart of internal job change management is shown in Fig. 3C. Contract management module: contracts and agreements require general management operations, such as signing contract agreements, changing contract agreements, handling expired contract agreements, rescinding contract agreements, viewing contract agreements, maintaining contract agreements, and managing contract change records. The flowchart of processing expired contract operations is illustrated in Fig. 3D. Logistic management module: the functions are interrelated and affect each other. Users can change one item and also change the attribute operations of other items. Each function module can update the system information in time, which is an advantage (Anwar and Riyanto 2019; Paredes et al. 2018).

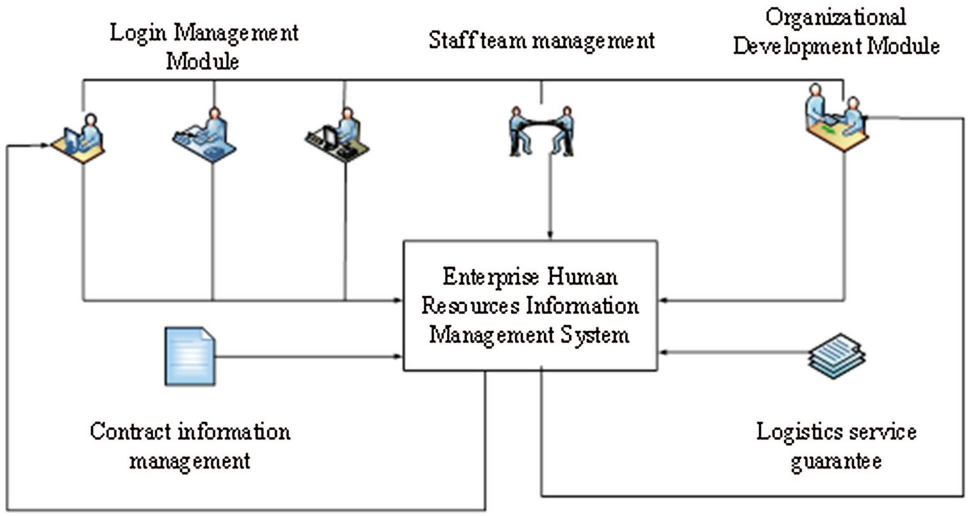

Fig. 1 Structure and function of corporate HRM system

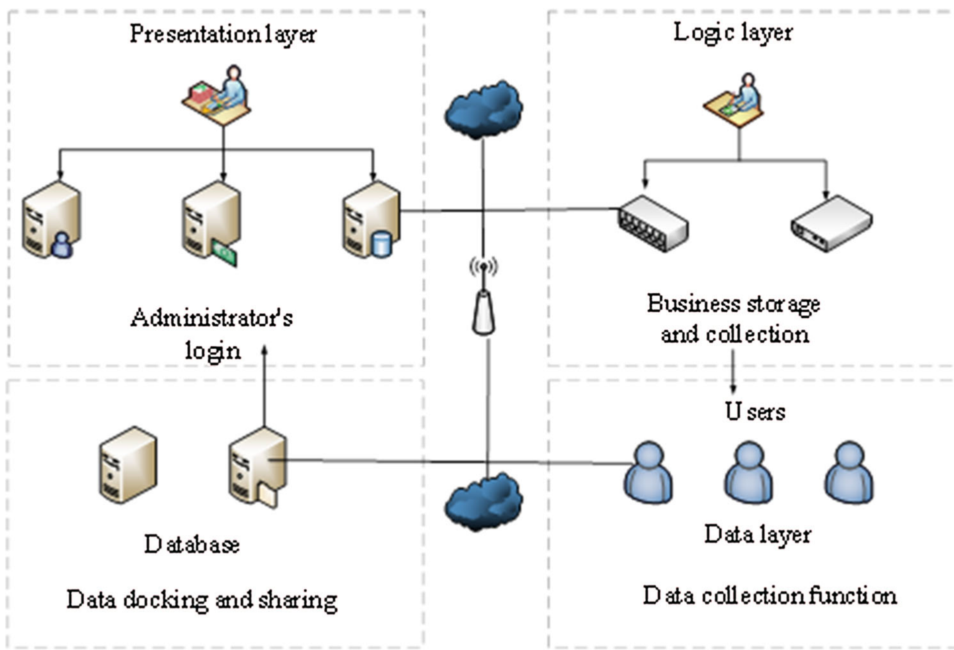

Fig. 2 System overall architecture

The Oracle database manages this system. The design of the system serves human resources to manage information better. Therefore, the database plays a major role in the working process of the system, and the reliability of the system is greatly affected by the database. Therefore, the common entity–relationship (E–R) diagram is used to accurately explain the database. The overall E–R of the system is demonstrated in Fig. 4.

3.4 Meta-heuristic algorithm optimization

Meta-heuristic algorithms can deal with complex problems and find the optimal processing approach from multiple implementation routes, which is feasible in solving problems in the HRM system (Jahannoosh et al. 2021). The system structure is designed using the genetic algorithm (GA). Due to the single-point search of the algorithm, the transmitted individuals should be set to a smaller amount. The adaptive design is adopted, and the specific equation is as follows:

$$\text{mize} = \begin{cases} \text{popsizeTS} \\ \text{popsizeTS} * A * \exp(1-g)/(\max+1-g) \end{cases} \tag{1}$$

In (1), N represents the interval of the grading function, A denotes the fixed coefficient, max describes the maximum evolutionary algebra, g represents the number of transfers, and popsize TS denotes the number of populations. The particle swarm optimization (PSO) algorithm is

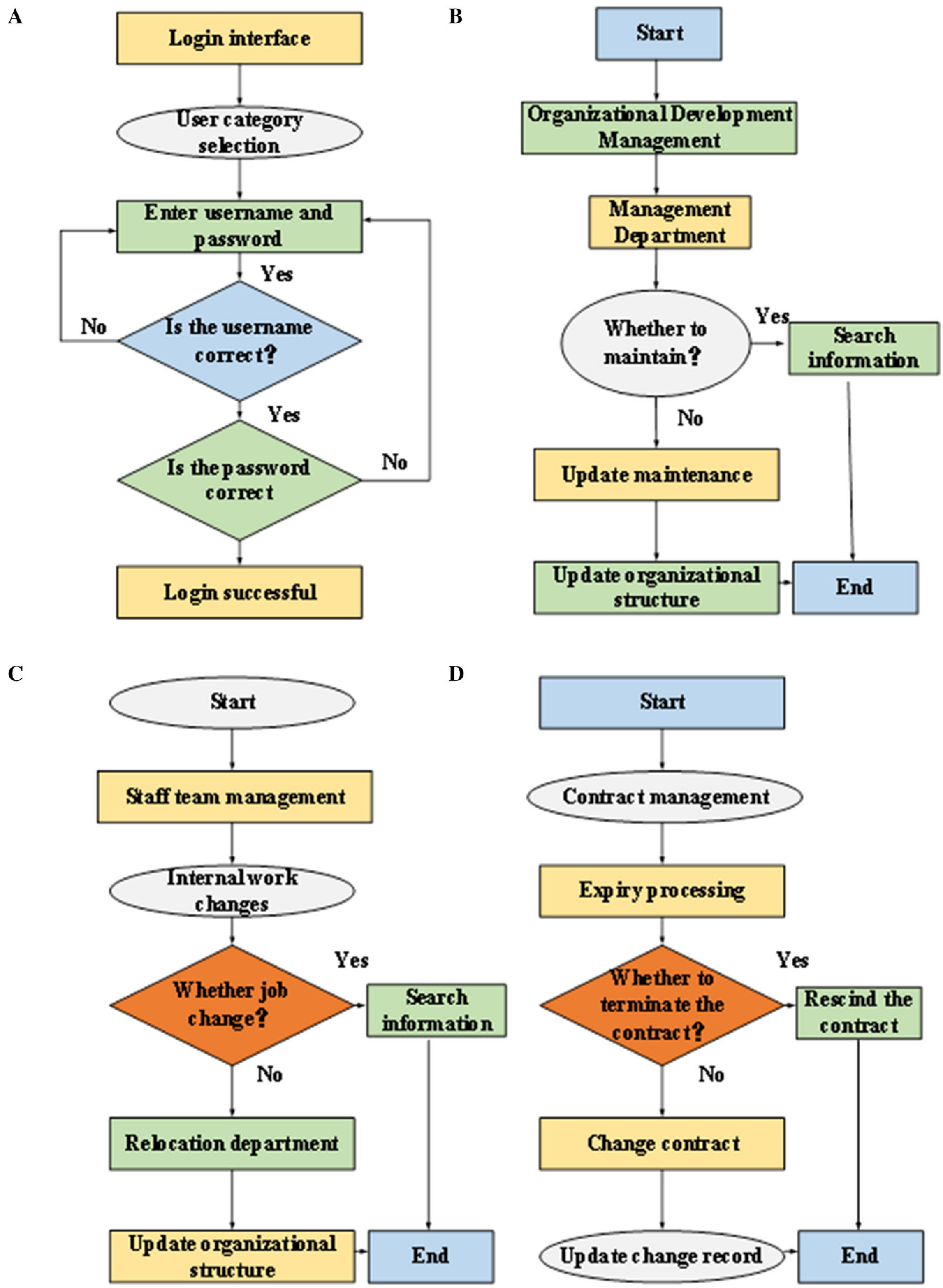

Fig. 3 Workflows of different management modules (**A**. detailed login steps; **B**. flowchart of organization management operation; **C**. flowchart of internal work change management; **D**. flowchart of processing expired contracts)

employed to collect and sort out the data. First, the particles are coded. Before a decision is made, particles in the particle swarm will be expressed as the time for each step and its priority. Then, the fitness value of the function is

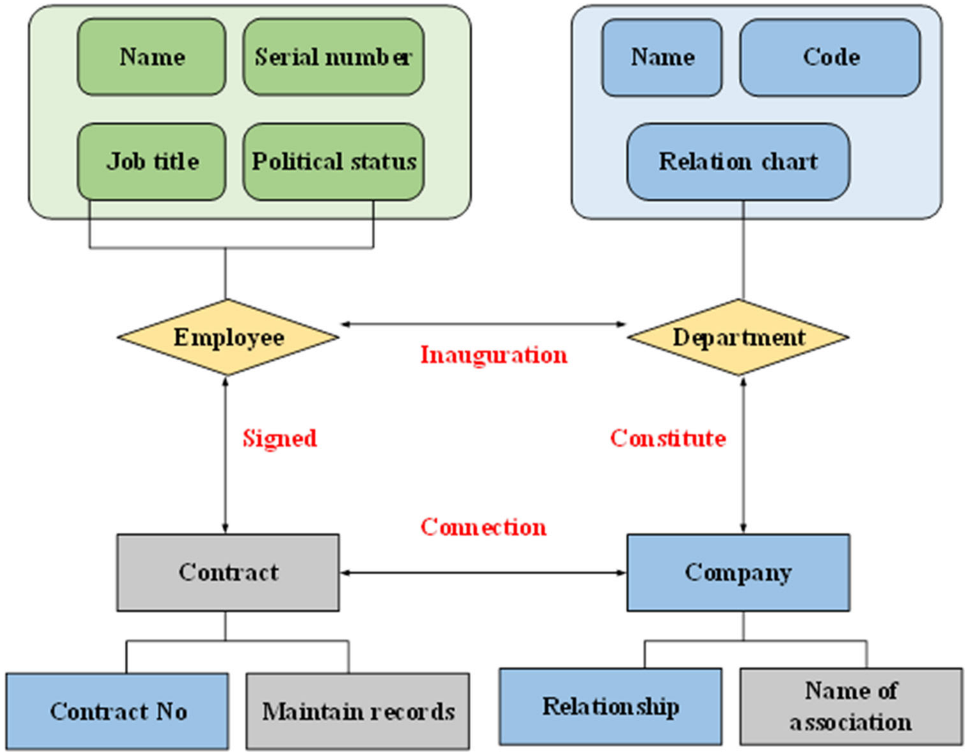

Fig. 4 Database design

obtained, and the position of each particle is expressed as a decision. The PSO algorithm is improved, and the inertia weight in the algorithm is optimized. The state equation is as follows:

$$w = w_{\min} + (w_{\max} - w_{\min}) \times \exp\left[-m\left(\frac{t}{t_{\max}}\right)^2\right] \tag{2}$$

In Eq. (2), m is the control factor for controlling the smoothness of the change curves w and t, whose value is 3. $w_{\max}$ represents the maximum value of inertia weight, $w_{\min}$ denotes the minimum value of inertia weight, $w_{\max} - w_{\min}$ means the difference between the extreme values of inertia weight, and $t_{\max}$ refers to the maximum iteration time. To prevent the particles in the population from stagnation in the iteration process, a mutation mechanism is added in the whole process of the algorithm, if it occurs before the algorithm stops. In case of stagnation, mutation treatment shall be carried out. The specific calculation is as follows:

$$\text{if}(x_i(t)) = x_i(t-1) = x_i(t-2) = x_i(t-n) \text{ and } x_i(t \neq \eta) \tag{3}$$

$$\text{then } x_i(t+m+1) = x_{\min} + \text{rand } (0,1) \times (x_{\max} - x_{\min}) \tag{4}$$

where x_i represents the population at any time, t is the iterative time, η refers to the minimum value of the fitness function in the whole population, the maximum number of iterations allowed to stagnate, and $(x_{\max} - x_{\min})$ denotes the search range. Set the maximum number of iterations to 1500, the number of runs of the algorithm to 20, and take the average value as the final result. Hardware environment: CPU: Intel (R) core (TM)2DuoCPUE8400@3.00 GHz; memory: 2 GB DDR3 1066 MHz, hard disk: 320 GB SATA, graphics card: GeForce GTX 460, quantity: 3. Software environment: operating system: Linux, windows 10, browser: Microsoft IE8, Mozilla Firefox, Google browser.

4 Results and analyses

4.1 Current status of information system

Figure 5A illustrates the age distribution of HRM in the enterprise, and Fig. 5B indicates the education distribution of HRM in the enterprise. Managers are generally older, accounting for 60% over the age of 40, while only 25% under the age of 35. Human resource managers generally have long working years and poor acceptance of new knowledge.

The educational level of management personnel is low, and the educational level of bachelor degree or above accounts for only 15%. The educational level of most personnel is at the college level. With the continuous improvement of the demand for the cultural level of talents, the professional quality level of human resources management personnel in the enterprise has been far from meeting the requirements.

Figure 6A signifies the training of personnel of the enterprise, and Fig. 6B illustrates the attitudes of different management levels of the enterprise toward the HRIS. The proportion of personnel receiving system education is less than 50%.

Most human resources still rely on past work experience to complete their daily work. Most of the respondents think that they can meet the requirements, with a proportion of 70%, especially the top management. The company executives have a certain understanding of informatization.

As shown in Fig. 7, Fig. 7A displays the investigation results of the reasons for the low efficiency of the existing management information system, and Fig. 7B presents the implementation effect of human resources informatization. The imperfect function is the main factor affecting work efficiency, accounting for 86.7%.

According to the feedback of employees on the implementation effect of human resources informatization, they generally feel that the improvement effect of personnel data management is obvious, greatly improve work efficiency, and the scores of recruitment system, training system and performance system are generally low. Therefore, the work of the enterprise in this field needs to be further improved.

As shown in Fig. 8, Fig. 8A shows the survey results of module application and Fig. 8B signifies the efficiency of personnel affairs management module. The use of the enterprise human resources management information system module is not ideal, and only the utilization rate of personnel affairs management module barely meets the requirements. Less than 45% of them actually use personnel affairs management as a tool for daily work.

Although the utilization rate of personnel affairs management is very high, it is rare to deal with human resources affairs. Most of them are supplemented after the event, and some are not even recorded. It directly leads to the untimely update of personnel file information of the enterprise, which is not conducive to the unified scheduling of personnel by the enterprise.

4.2 Model performance comparison

Figure 9 presents the performance comparison results of different algorithms.

As shown in Fig. 9, Fig. 9A illustrates the relationship between the objective function value and work events under given resource conditions, Fig. 9B denotes the relationship between CPU time and workpiece events, Fig. 9C signifies the relative optimization percentage results of CPU (central processing unit) time, and Fig. 9D presents the processing time results under different events.

It is not difficult to find that with the increase in the number of events, the solution time of the objective function is increasing. When the number of events is greater than 5, the system time increases sharply, resulting in the rapid acceleration of the CPU processing speed. However, the optimization percentage of the objective function value is generally low, no more than 5%. This shows that there are some limitations in simply relying on the improved heuristic algorithm to find a better solution, but it also shows that the initial solution obtained by the algorithm has room for further optimization.

The objective function value and optimal curve under different events and different algorithms are shown in Fig. 10:

As shown in Fig. 10, Fig. 10A shows the objective function values of different algorithms under 6 events,

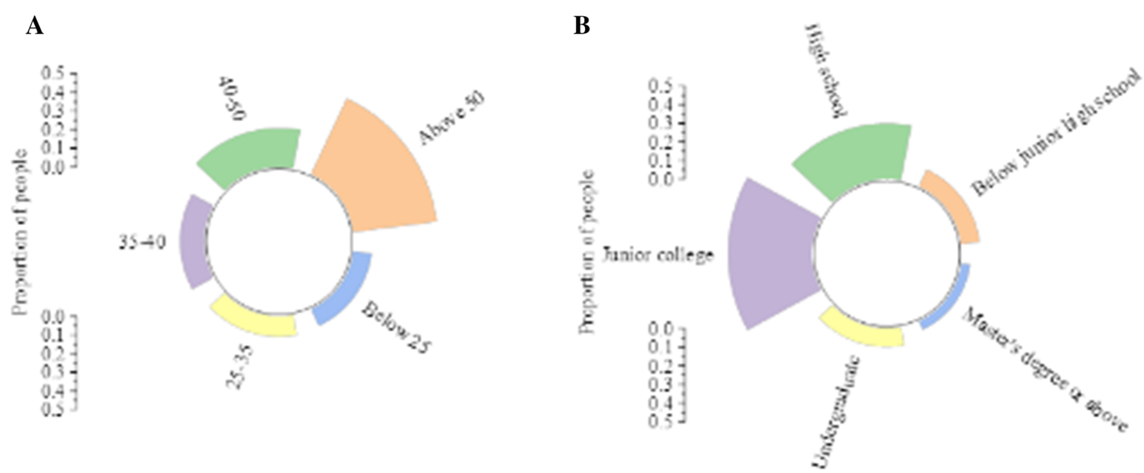

Fig. 5 Age and educational background distribution of HRM in the enterprise (**A**. the age distribution of HRM in the enterprise; **B**. the educational background distribution of HRM in the enterprise)

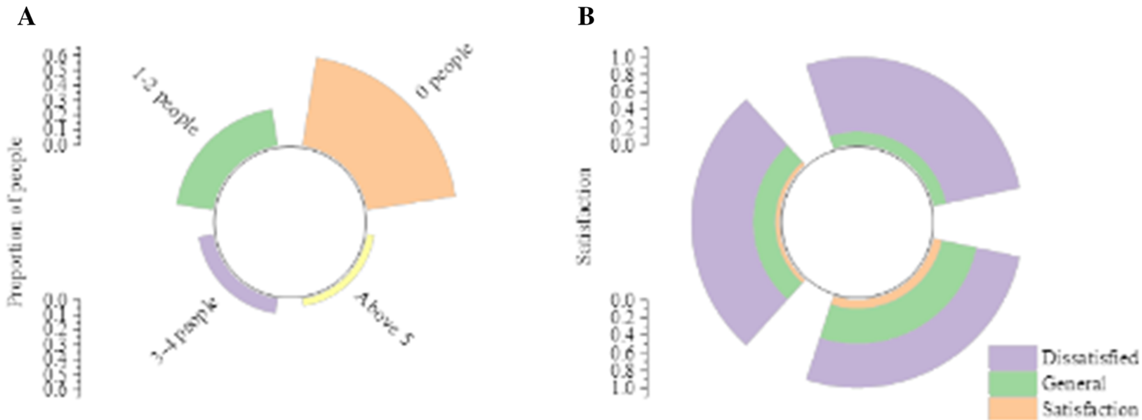

Fig. 6 Distribution of employees; training and attitude toward the system (**A**. the training of employees of the enterprise; **B**. the attitude of different management levels of the enterprise toward the HRIS)

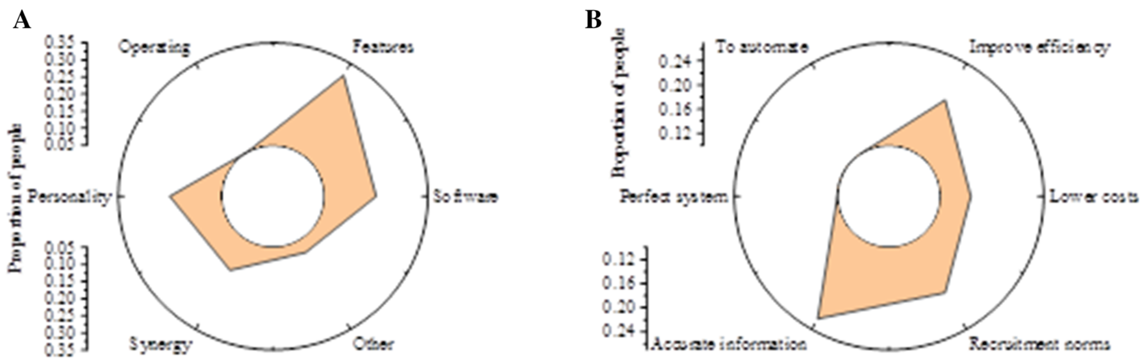

Fig. 7 Management information system problems and their effect evaluation (**A**. the reasons for the low efficiency of the existing management information system; **B**. the implementation effect of human resources informatization)

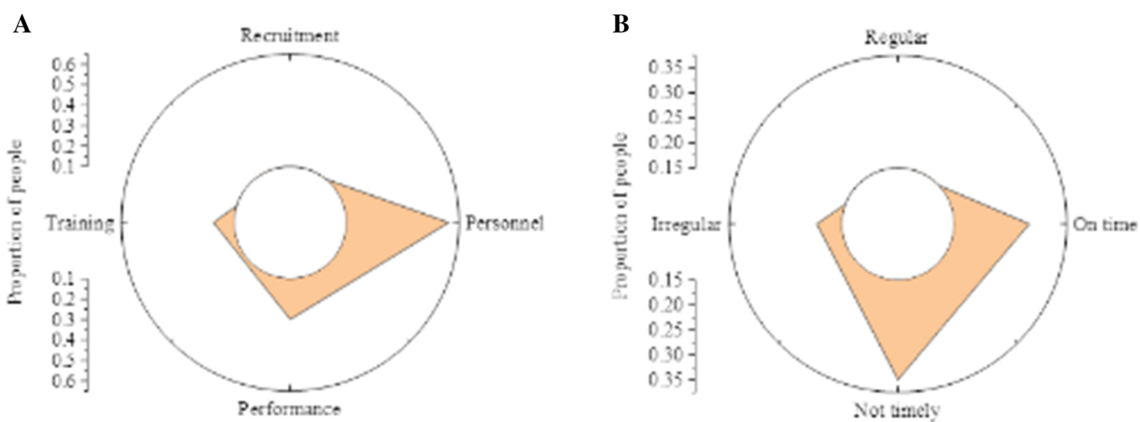

Fig. 8 Module application and personnel affairs management module efficiency (**A**. the research results of module application; **B**. the efficiency of personnel affairs management module)

Fig. 10B denotes the objective function values of different algorithms under 12 events, Fig. 10C reflects the objective function values of different algorithms under 24 events, and Fig. 10D displays the variation curve of the optimal objective function value of the current iteration with the number of iterations. The optimal solution ability of the algorithm is improving with the increase in the number of events. Besides, it decreases with the increase in the number of iterations, and all converge in about 80 generations, which just reflects the process of intelligent search optimization of PSO algorithm.

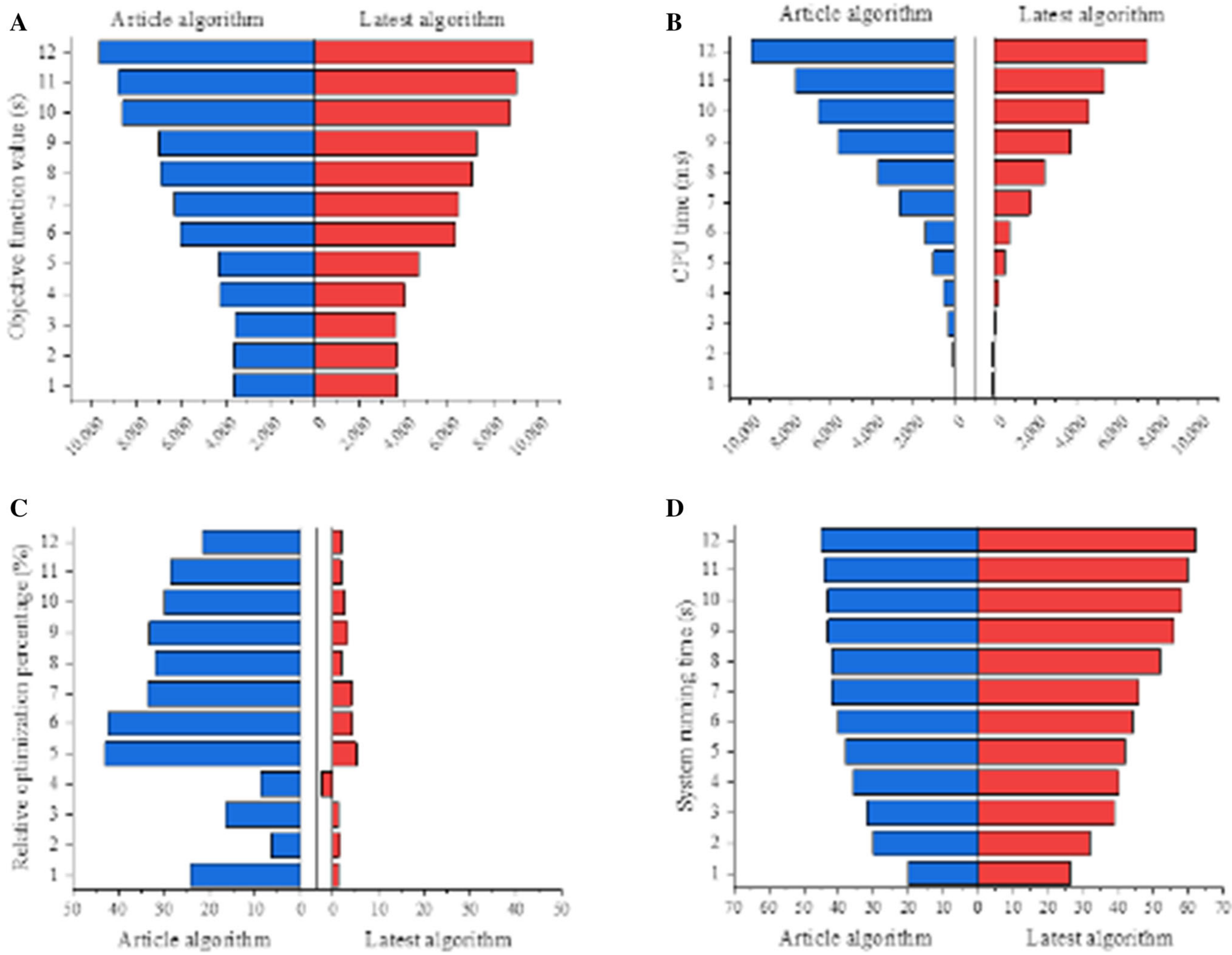

Fig. 9 Performance comparison results of different algorithms (**A**. the relationship between the objective function value and work events under given resource conditions; **B**. the relationship between CPU time and workpiece events; **C**. the relative optimization percentage result of CPU time; **D**. the processing time result under different events)

It shows that after the number of iterations, the pheromone of the better solution continues to strengthen, so that the search gradually converges to the attachment of the better solution, so that the curve shows a relatively stable trend. The optimization efficiency of this model reaches 86.35%; under the same number of iterations, the system can find the optimal solution in a shorter time, which is more efficient than the existing research results in this field.

4.3 information clustering effect

As shown in Fig. 11, Fig. 11A illustrates the employee performance data before clustering and Fig. 11B shows the employee performance data after clustering. After clustering by our system, there are 8 abnormal data and 92 normal data in the right figure, and the accuracy rate of employee performance reaches 92%

The results show that most of the performance data are effective, and the density around the core points is almost scattered. Eight outliers exist as noise, and the serial number of noise data will be returned after clustering, so it can correspond to the number of abnormal data. Therefore, the system can find the corresponding employee number and related information in the database. In the HR manager interface, the employee number with abnormal data will be prompted to change or maintain employee performance data. The subsequent data analysis eliminates the occurrence of abnormal conditions and provides an additional layer of insurance measures for the construction of charts such as performance structure chart, which is consistent with the existing research results in this field.

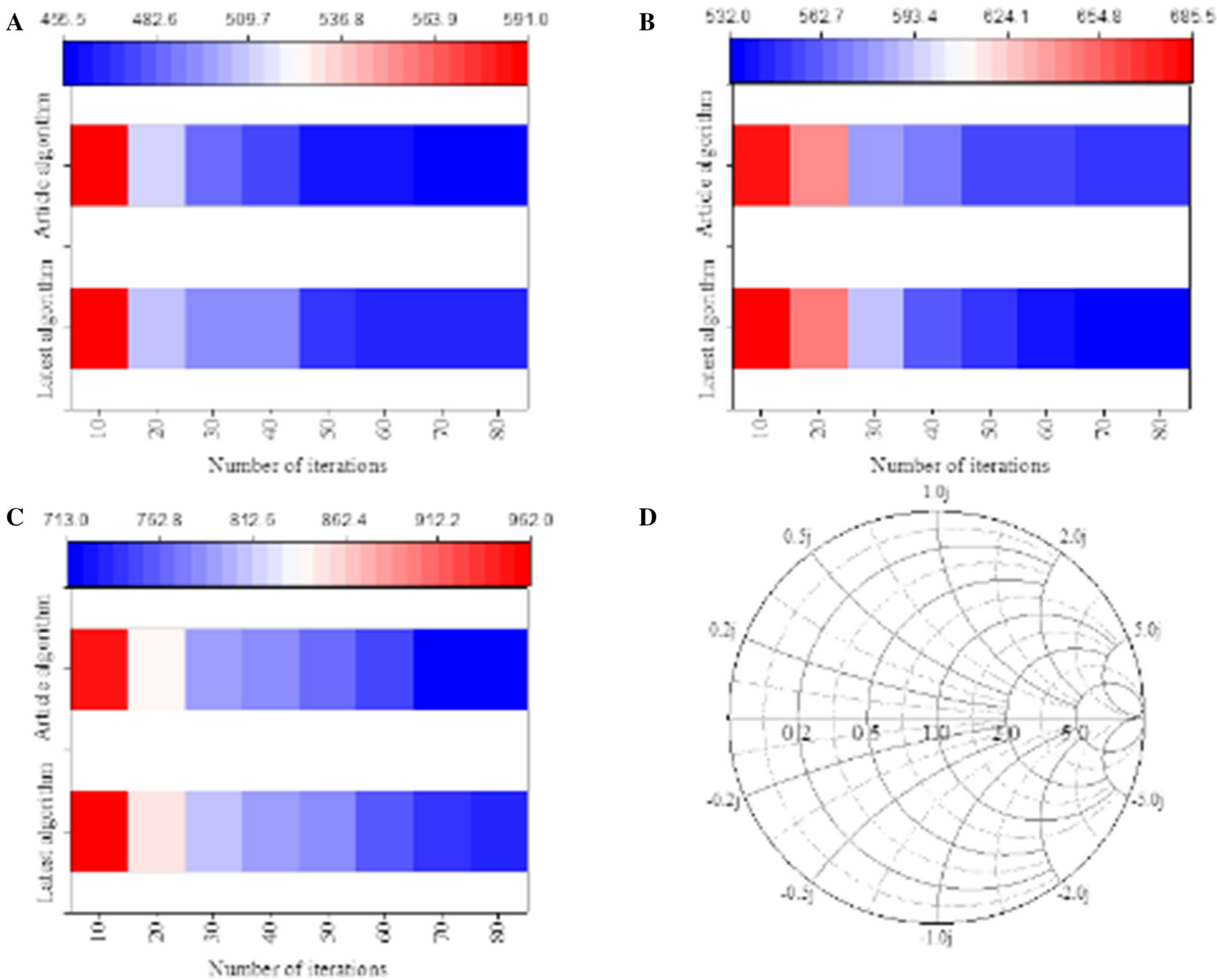

Fig. 10 Objective function value and optimal curve under different events and different algorithms (**A**. the objective function value of different algorithms under 6 events; **B**. the objective function value of different algorithms under 12 events; **C**. the objective function value of different algorithms under 24 events; **D**. the variation curve of the optimal objective function value of the current iteration with the number of iterations)

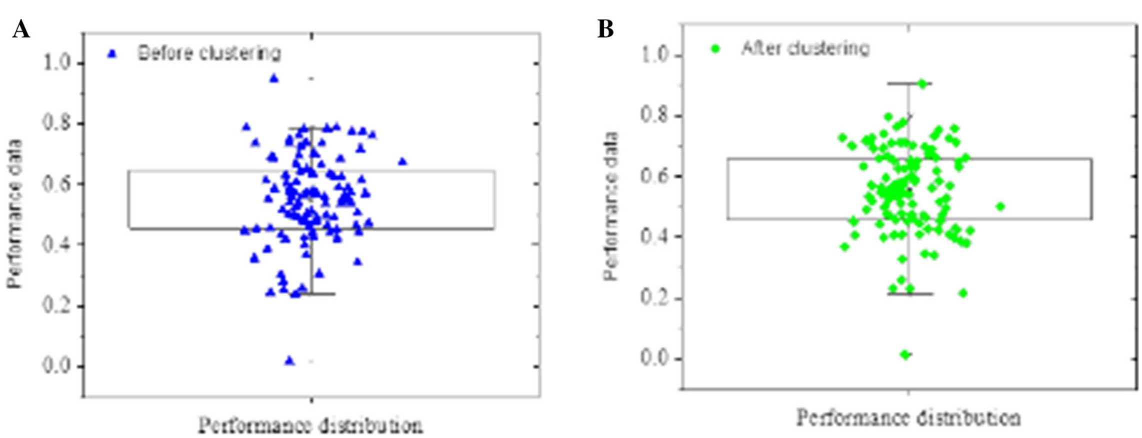

Fig. 11 Information clustering effect analysis (**A**. employee performance data before clustering; **B**. employee performance data after clustering)

5 Conclusion

A company is taken as an example, based on full investigation, what is found are the problems existing in the current human resource information management system. Through analyzation of its needs in HRM, relevant systems are developed, and construction is realized on an intelligent enterprise HRM information system by using java programming language, web application system and B/S framework. Aiming at the complexity of enterprise HRM, the meta-heuristic algorithm is used to optimize the human resource optimal scheduling module. As a result, the system is finally realized. After the system clustering in this paper, the accuracy rate of employee performance reaches 92%. The practical significance of the research is that compared with the current research status of algorithms in HRM system, it is found that our proposed algorithms and systems have certain advantages, which can effectively improve the company's HRM level and HRM development, and have reference significance.

Although the corresponding management system is designed and developed, there are still many problems: first, carrying capacity of this system is limited. When the system is too busy, it will lead to a decline in response speed, which will seriously affect the use satisfaction of enterprises. Besides, with the continuous increase in enterprise data, the system has a certain degree of delay. In the future, the algorithm of deep learning neural network will be adopted to improve the data processing efficiency of the system through cloud computing or edge computing.

Author contributions Sixuan Chen contributed to the writing and proposed the research direction. Huan Xu was involved in the analysis of the experimental data; all correspondence regarding this article.

Funding This work was supported by the Natural Science Foundation of China (Grant No. 72002095) and the Jiangsu University Philosophy and Social Science Foundation of China (Grant No. 2020SJA0025) and The Fundamental Research Funds for the Central Universities (Grant No. 30921012203) in China.

Declarations

Conflict of interest The authors declare that there is no conflict of interest with any financial organizations regarding the material reported in this manuscript.

Ethical approval This study does not violate and does not involve moral and ethical statement.

Informed consent All authors were aware of the publication of the paper and agreed to its publication.

References

Almeida F, Silva P, Araújo F (2019) Performance analysis and optimization techniques for oracle relational databases. Cybern Inform Technol 19(2):117–132

Anwar C, Riyanto J (2019) Perancangan sistem informasi human resources development pada pt semacom integrated. Int J Edu Sci Technol Eng 2(1):19–38

Bali AS (2019) An analytical study of applications of human resource information system in modern human resources management. Int J Sustain Agric Manag Inform 5(4):216–229

Barišić AF, Poór J, Pejić Bach M (2019) The intensity of human resources information systems usage and organizational performance. Interdiscip Descr Complex Syst: INDECS 17(3-B):586–97

Basheer M, Siam M, Awn A, Hassan S (2019) Exploring the role of TQM and supply chain practices for firm supply performance in the presence of information technology capabilities and supply chain technology adoption: a case of textile firms in Pakistan. Uncertain Supply Chain Manag 7(2):275–288

Bo H, Han P, Lu B, Zhao C, Wang X (2021) Online monitoring and collaborative scheduling method for wheelset cyber-physical production system: a wheelset manufacturing system case study from a Chinese high-speed train enterprise. Adv Eng Inform 47:101210–101216

Bowden JA, Ulmer CZ, Jones CM, Koelmel JP, Yost RA (2018) NIST lipidomics workflow questionnaire: an assessment of community-wide methodologies and perspectives. Metabolomics 14(5):1–11

Chaudhary R (2020) Green human resource management and employee green behavior: an empirical analysis. Corp Soc Responsib Environ Manag 27(2):630–641

Duan Q, Quynh NV, Abdullah HM, Almalaq A, Do TD, Abdelkader SM, Mohamed MA (2020) Optimal scheduling and management of a smart city within the safe framework. IEEE Access 8:161847–161861

Jahannoosh M, Nowdeh SA, Naderipour A, Kamyab H, Davoudkhani IF, Klemeš JJ (2021) New hybrid meta-heuristic algorithm for reliable and cost-effective designing of photovoltaic/wind/fuel cell energy system considering load interruption probability. J Clean Prod 278:123406

Jawad WK (2020) Design and implementation of e-human resource manaement system for IT company. Int J Sci Res Eng Develop 3(1):124–131

Jean AT, Wang X, Suntu S (2020) Corporate social responsibility in Madagascar: an investigation on Chinese companies. Int J Constr Manag 20(1):29–38

Kamaludin K, Kamaludin KZ (2017) User acceptance of the human resource information system: a study of a private hospital in Malaysia. Int Rev Manag Mark 7(2):207–217

Kianto A, Sáenz J, Aramburu N (2017) Knowledge-based human resource management practices, intellectual capital and innovation. J Bus Res 81:11–20

Li C, Li J, Chen H, Heidari AA (2021) Memetic harris hawks optimization: developments and perspectives on project scheduling and QoS-aware web service composition. Expert Syst Appl 171:114529–114536

Liu P, Qingqing W, Liu W (2021) Enterprise human resource management platform based on FPGA and data mining. Microprocess Microsyst 80:103330–110336

Ma Z, Wang S, Shen J, Li S, Shi Y (2019) Design of multi-energy joint optimization dispatching system for regional power grids based on B/S architecture. Energy Procedia 158:6236–6241

Margatama L (2017) Employee self service-based human resources information system development and implementation. Case Stud: BCP Indones J Inform 11(1):52–60

Masum AKM, Beh L-S, Azad MAK, Hoque K (2018) Intelligent human resource information system (i-HRIS): a holistic decision support framework for HR excellence. Int Arab J Inf Technol 15(1):121–130

Papa A, Dezi L, Gregori GL, Mueller J, Miglietta N (2018) Improving innovation performance through knowledge acquisition: the moderating role of employee retention and human resource management practices. J Knowl Manag 24(3):212–231

Paredes MA, del Pilar Salas-Zárate M, Colomo PR, Gómez-Berbís JM, Valencia-García R (2018) An ontology-based approach with which to assign human resources to software projects. Sci Comput Program 156:90–103

Qadir A, Agrawal S (2017) HR transformation through human resource information system: review of literature. J Strateg Human Res Manag 6(1):30–36

Samsai T, Praveena S, Kowshika S (2018) A study on demand analysis of farm machineries and equipments in Nilgiris district. Int J Commer Bus Manag 11(1):59–68

Shahreki J (2019) The use and effect of human resource information systems on human resource management productivity. J Soft Comput Decis Support Syst 6(5):1–8

Shirvani MH (2020) A hybrid meta-heuristic algorithm for scientific workflow scheduling in heterogeneous distributed computing systems. Eng Appl Artif Intell 90:103501–103511

Skobelev P, Simonova E, Smirnov S, Budaev D, Voshchuk GY, Morokov A (2019) Development of a knowledge base in the "smart farming" system for agricultural enterprise management. Procedia Comput Sci 150:154–161

Tantoh HB, Simatele D (2018) Complexity and uncertainty in water resource governance in Northwest Cameroon: reconnoitring the challenges and potential of community-based water resource management. Land Use Policy 75:237–251

Wang T (2020) Intelligent employment rate prediction model based on a neural computing framework and human–computer interaction platform. Neural Comput Applic 32:16413–16426

Yang B, Wang J, Zhang X, Yu T, Yao W, Shu H, Zeng F, Sun L (2020) Comprehensive overview of meta-heuristic algorithm applications on PV cell parameter identification. Energy Convers Manage 208:112595–112603

Zhao W, Wang L, Zhang Z (2019) Artificial ecosystem-based optimization: a novel nature-inspired meta-heuristic algorithm. Neural Computing and Appl, 1–43

Zhu J, Sun Y (2020) Dynamic modeling and chaos control of sustainable integration of informatization and industrialization. Chaos, Solitons Fractals 135:109745–109753