ISSN 1330-3651 (Print), ISSN 1848-6339 (Online)
https://doi.org/10.17559/TV-20230810000869
Preliminary communication

Research on Risk Prediction and Early Warning of Human Resource Management Based on Machine Learning and Ontology Reasoning

Miaomiao TANG*, Tianwu ZHAO, Zhongdan HU, Qinghua LI

Abstract: Talent is the first resource, the development of the enterprise to retain key talent is essential, the main research is based on machine learning and ontological reasoning, human resources analysis and management risk prediction and early warning methods, first of all, according to the specific situation and the target case, through the calculation of the similarity of the concept name and attribute of the similarity assessment of the source case in the case library, the matching of knowledge-based employees of the company's case for the similarity prediction and human resources management risk prediction research. Then, according to the evaluation results, we can find out the most suitable job matches in specific risk problems and situations. This is a solution to the target cases and criteria for companies to evaluate candidates. Second, we have successfully developed and implemented a prediction model that applies machine learning to the early warning study of risk prediction for HR management. The model is optimized with a cross-validation function, and the convergence of the model training is accelerated by the regularization of Newton's iterative method. Finally, our prediction model achieved 82% yield. Ontological reasoning and machine learning are promising in human resource management risk prediction and warning, which is proved by the high accuracy rate verified by examples. Finally, we analyze the proposed results of HRM risk prediction and early warning to contribute to the improvement of risk control and suggest measures for possible risks.

Keywords: human resource management; machine learning; ontology reasoning; regularization; risk prediction

1 INTRODUCTION

Enterprise strategy has become a part of the enterprise strategic management, human resource management of the enterprise to obtain the maximum effectiveness of the talent important impact, relying on technological innovation and talent development, and ultimately realize the development of human resources of large enterprises. The 21st century is the era of knowledge-based economy, digital economy, and competition for talent, and the only way for enterprises to occupy a favorable position in the fierce competition is to have a strong and mature human resource management system. In the face of such a severe situation, enterprises have increased the participation of human resource management, and improved the human resource risk outlook and early warning from all aspects. If enterprises want to improve the level of risk prediction and early warning of human resource management, they should start from limiting the risk, take the initiative to find and excavate the danger, take appropriate measures to limit the danger, and should maximize the level of human resources. Resource Management Risk Prediction and Early Warning [2]. In view of the traditional personnel management risk prediction and early warning system cannot meet the needs of the enterprise big data in order to make the system work properly, the current need for massive data manual screening and processing to reduce the amount of big data, but this processing seems to return to the era of the old data, seriously hindering the improvement of the efficiency of the work of human resource management risk prediction; and early warning system (HR) [3] plays an important role, and some people have proposed the use of Data Mining [4] to reduce the data that need to be processed, and the purpose of Data Mining is to analyze and discover the data patterns of the massive raw data, and ultimately transform the raw data into useful information and knowledge.

Data Mining utilizes various techniques and statistical methods to mine useful information and knowledge from massive data. There are many commonly used data mining techniques, and machine learning methods are one of the most important ones. Machine learning can use the data to train and summarize the learning experience and finally get the analysis and understanding model based on the training results, so the effective use of machine learning technology can help us understand and analyze the data. At the same time, it also brings a new development direction for HR risk prediction and early warning, i.e., using machine learning methods to improve the ability of HR risk prediction and early warning system to manage and analyze data. With the increasing maturity of artificial intelligence technology, the application of electronic personnel management risk prediction and early warning and electronic labor platform in employees' posts continues to deepen, and intelligent recruitment system, social network application and electronic labor platform emerge as The Times require. How to build a model? A large number of locations and multi-semantic resources can be shared and reused, and their similarity can be accurately measured. Based on ontology, machine learning methods are used to enhance HR risk prediction and data analysis capabilities. How to construct models to share and reuse the multiple semantic resources of massive jobs and accurately measure their similarity, and provide technical support for semantic matching of people and jobs with ontology case reasoning technology, is the key to intelligent matching of people and jobs. Therefore, it is of great practical significance to utilize machine learning and ontological reasoning technology in HRM risk prediction and early warning system.

2 RELATED WORK

Machine-Learning is one of the main tools to realize data mining, which is applied in various fields, including of course the HR risk prediction and warning field. So far, the application of machine learning and ontological reasoning in the field of HR risk prediction and early warning has been studied in a large number of researches and the content of the research also involves many aspects, such as the extraction of data and so on. Literature [5, 6] analyzes in detail the important role of Data Mining for

preventing talent loss and improving the accurate management of human resources, and predicts and warns HR management risks. Literature [7] demonstrates the ability of Data Mining to improve the quality of decision-making process in HRM risk prediction and early warning system. Literatures [8, 9] analyzed and realized the application of Data Mining in risk prediction and early warning management of human resource management. Literature [10] proposed a data mining model to help organizations predict the future performance of employees and then assign the right people to the right tasks and projects. Literature [11] proposed a fuzzy clustering method based on adaptive genetic algorithm to provide effective data analysis for assessing employee performance in human resource risk prediction and early warning in modern organizations. Literature [12] designed and implemented a human-job matching degree measurement model, which can provide effective allocation of human resources by using machine learning and ontological reasoning techniques. Literature [13] proposed a new method for evaluating job applicants in an online recruitment system and solved the applicant ranking problem using machine learning and ontological reasoning algorithms. Literature [14] investigated six scenarios of artificial intelligence in risk prediction and manpower forecasting, Resource Alerting, which are Artificial Neural Networks Flow Prediction, Knowledge Based Candidate Search and Genetic Algorithm Staff Scheduling, HR Sentiment Analysis with Text Mining, Resume Data Collection and Information Extraction with Interactive Voice Response and Employee Self-Service. Literature [15] designed an improved algorithm with good practical reference value based on support vector regression for HR demand forecasting in enterprises. In [16], Extreme Gradient Boosting (XGBoost) is applied to predict the turnover rate of employees to solve the problem of turnover, and it is proved that its accuracy in predicting the turnover rate is higher than that of other supervised classifier algorithms. Literature [17] analyzes the factors affecting employee exit based on the generalization of working life and creates an exit prediction model that can provide a solution to the HR exodus problem, using machine learning and ontological reasoning. Literature [18] implements a HR ranking model, which can predict the sorting and classification of personnel resumes with very high accuracy, and simplify HR work reasonably and effectively. Literature [19] proposed a normal human resource recommendation algorithm (HR) based on the hidden semantic model and DeepForest to better recommend jobs of interest for users. Literature [20] seeks to understand whether machine learning and ontological reasoning can be effectively used to perform potential assessments to help or even replace HR managers (HR) by using a preventive approach. Literature [21] utilizes machine learning and ontological reasoning to provide support for HR decision making. Literature [21] establishes an employee HRM risk prediction and early warning model, based on support vector machines, which can predict employee turnover in an organization and provide the opportunity for the organization to solve any problems and improve the retention rate. Literature [22] utilizes supervised machine learning and ontological reasoning techniques to predict suitable human resources to fill vacancies in technical job positions in order to solve the problem of human resource turnover in technical job positions. All these indicate that machine learning and ontological reasoning are expanding their influence in the human resource field and are promising in improving the efficiency and performance of risk prediction and early warning systems for human resource management.

According to the research, the intelligent technology of man-post matching knowledge ontology [23] refers to the realization of sharing and continuous reuse of rational knowledge elements of man-post matching between semantically consistent man-post matching knowledge ontologies by defining unified term concepts, attributes and relationships in the field of man-post matching, and by calculating similarity of mapping and mapped results in the context of the development of Internet technology. In the context of the development of Internet technology, by defining the field of man-place matching, the academic community is applying knowledge ontology to the research on risk prediction and early warning of human resource management. Compared with other fields, the theoretical research of knowledge ontology in personnel, position and organization matching mainly lies in the construction and improvement of the basic overall framework of human resource knowledge ontology. The construction and continuous improvement of this theory will enable other scholars to conduct more automated and intelligent practical research on human-earth matching system on this basis, and apply it to other research on risk prediction and early warning of human resource management in the forecasting field. This paper studies the overall framework and development of human resource management and early warning of knowledge ontology [24], so that knowledge reuse, standards and classification are widely integrated to form representative capability concepts such as education, employment, industry, post, organization, skills and personnel sub-ontology. Further research on the overall framework of HR knowledge ontology [25] describes the reference ontology as a common language and expresses it in the form of vocabulary, which saves time for the whole system development process. Other researchers [26, 27] also conducted a detailed study on the overall framework of HR knowledge ontology and provided some general human resource development vocabulary. An important practical result of the practical research on human and post-data ontology intelligent matching is the research on human and post-data ontology intelligent matching in the field of human resource risk prediction and early warning based on actual combat. It built an automated human-information matching system. In the initial phase, the proposed HR-information system should be dynamic in order to optimize the compatibility of personnel positions, but the system studied at the time may not produce a set of criteria for each position [28]. Therefore, all jobs can only be divided into clusters or working groups corresponding to employees, based on the similarity of job requirements. For example, cluster analysis based on empirical data shows how to create an efficient job classification system [29] where criteria can be used to search for potentially good applicants in the same cluster. The main research results of post-data ontology intelligent matching research in the field of personal risk prediction and early warning based on HR risk prediction and early warning are practical research based on future data ontology intelligent matching. Another practical result in the field of HR risk prediction and early warning is knowledge reasoning ability. Some studies have found that in addition to information sharing and reuse [30], information can also support the reasoning

of implicit information, promote the interoperability of heterogeneous information services, ultimately enabling search and inference operations of these capabilities to achieve longer term interoperability and collaboration between different information services.

As far as the current situation is concerned, the application of machine learning and ontology reasoning in HR risk prediction and early warning is still in its infancy, and the application field is still relatively narrow. Most applications only involve recruitment management, resource management, early warning management and other parts of human resource management risk prediction and early warning, and have not yet involved other fields such as talent training and contract management. Although not all HR risk prediction and early warning modules can apply machine learning technology to solve relevant problems, with the continuous development of machine learning technology, it will certainly spread to most areas of HR risk prediction and early warning, and finally realize the management and analysis of HR data.

3 RESEARCH ON HUMAN RESOURCE MANAGEMENT FORECASTING AND EARLY WARNING KNOWLEDGE BASED ON ONTOLOGY REASONING

3.1 Human Resource Management Risk Characteristic Ontology Construction

In the knowledge-based modern enterprise human resource management, the matching of the competence of the workforce must be considered more carefully than in the past. In the more complex description of talents and the need to exchange talent information between different organizations within the company to achieve automatic job hunting, the ability and other related concepts need to be described in a standardized way, and the information ontology with intelligent technology can be based on the organizational ability management and the intelligent matching of personnel after the data ontology. Based on the knowledge management construction of knowledge ontology and the concept of employee ability improvement based on ontology research, it covers four types: resources, theoretical knowledge, skills and behavioral ability. HR has developed a knowledge reference system model based on knowledge ontology that combines knowledge management with technology-enhanced workplace learning, with the goal of developing a knowledge-based operating system for capability management.

Combining the case retrieval method based on concept, attribute, similarity and semantic consistency, this paper proposes a person-post matching retrieval method based on ontology and case-based reasoning. Based on the Ontology and its reasoning mechanism, this method maps the case set and concept node of the job skill feature knowledge ontology in the form of an example to achieve the structured representation and storage of the case knowledge. In addition, it reviews and updates the ontology-CBR Case-Based Reasoning) hierarchical retrieval model in time, and collects the cases together in the form of examples to update and revise the cases.

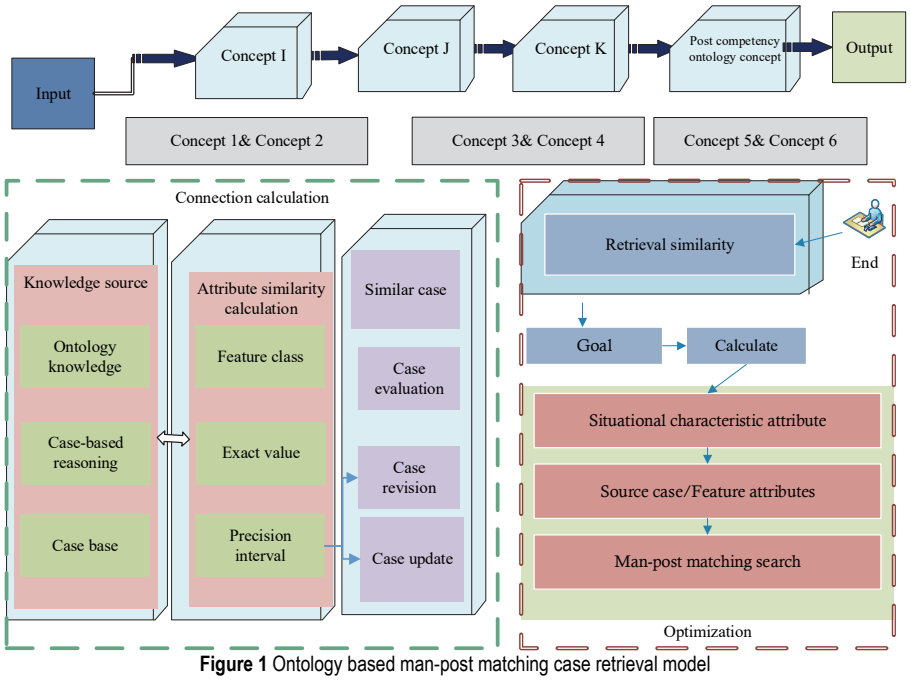

Figure 1 Ontology based man-post matching case retrieval model

As shown in Fig. 1, based on the qualitative retrieval of the position competency feature ontology, the similarity of the concept name is calculated through the concept name retrieval of the entire position competency feature domain ontology, and the available sub-case set with similar concepts to the target case is obtained, thus achieving the purpose of narrowing the case reasoning retrieval scope.

When a certain attribute value is text, the similarity of two different matching cases P_0, P_1 is calculated, that is, the similarity of attribute text features extracted in the human-post matching case is: the proportion of the total number of extracted text features in the total number of text features.

$$Sim(P_0, P_i) = \frac{N(P_0) \cap N(P_i)}{N(P_0) \cup N(P_i)} \tag{1}$$

$N(P_0)$ represents a set of text features extracted by attribute P_0 in the target case. The similarity of the text

features of the attribute is determined by the number of text features shared with the same attribute in the total number of text features of the two cases. In the preliminary screening case, through the retrieval of the concept name, the numerical similarity is further accurately calculated, and the numerical similarity of its attributes is quantitatively determined as follows.

$$Sim_{av}(F_0, F_1) = 1 - \frac{|F_1 - F_0|}{\mathrm{Max}(F_1 - F_0) - \mathrm{Min}(F_1 - F_0)} \tag{2}$$

The formula for calculating the similarity threshold is as follows:

$$\gamma_{av} = Sim_{av}(F_0, F_1) + \frac{1}{2} Sim\ (P_0, P_1) \tag{3}$$

3.2 Construction of Human Resource Management Risk Ontology Model

Assume that each user capability or job requirement is a classic topic modeling algorithm generated by mixing K topics. The probability distribution represented by each problem is the ability or need of the whole N. Skill file Y under the above conditions, the likelihood of the following formula gives the marginal likelihood value.

$$P(Y \mid \theta) = \int_{\theta} \prod_{L=1}^{N} P(Y_L \mid \theta) P(\theta_L) d_{\theta} \tag{4}$$

Then, according to the Laplacian approximation of softmax basis, O is used to represent the non-diagonal elements of the covariance matrix, and the approximate diagonal covariance matrix of large K is obtained.

$$U_L = \log \theta_k - \frac{1}{L} \log \theta_l \tag{5}$$

Then keep only the E skills that appear the most frequently before, so that there are not too many noisy skill labels appearing in the positions with more people. For latent skill variable s_j, the position attribute compound variable S can be transformed into a suitable potential space through a layer of MLP.

$$s_j = \theta(\gamma_{av} * s_{j-1}) + U_L \tag{6}$$

After the generation probability model is established, the common probability of the complete data u can be obtained by the following formula.

$$p(Y, S) = \prod_{i,j} p(\gamma_{ij} \mid u_i) \tag{7}$$

Observation data is represented by Y, which can be estimated on the basis of training models by the following methods:

$$E[\gamma_{ij} \mid Y] = E[u_i \mid Y] * E[u_i \mid Y]^T \tag{8}$$

For point estimates, the prediction is approximated as:

$$\gamma_{ij}^* = G(E(s_i))^T u_j \tag{9}$$

Therefore, according to the above structural analysis, concepts and attributes contained in personnel job matching cases are separated by introducing the knowledge ontology form of personnel job matching competency feature field, thus forming the ontology retrieval layer, and the retrieval process of target cases can be divided into multiple levels. On the basis of the above analysis, the search of person-post matching cases in this paper is divided into the following three specific similar calculation steps:

STEP 1: According to the human-job matching domain data ontology, the semantic similarity of the ontology is calculated based on the concept name, the semantic differences are excluded, and the available case set is initially extracted.

STEP 2: According to the content represented by the case information, the similarity of the case is calculated based on the attribute, and the set of similar cases is screened;

STEP 3: Establish the employee position matching graph, the similarity threshold reaches the threshold, build a group of similar cases for matching, and then the matching ends. If the source cases are not satisfied, repair or update the source cases, and mark the employees with risk factors. The specific calculation method is shown in Fig. 2:

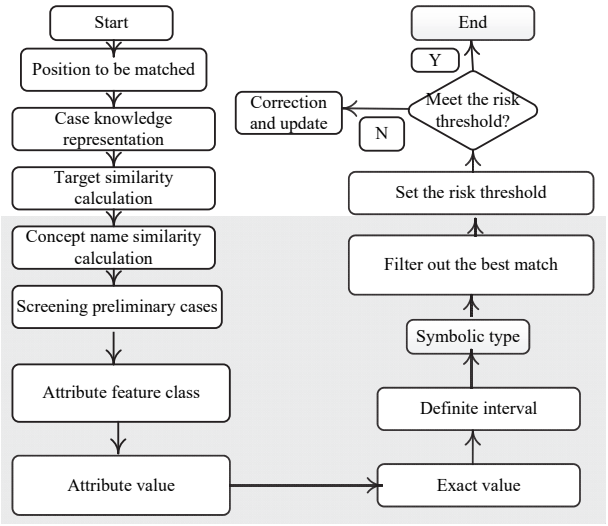

Figure 2 Research framework of similarity calculation for person-post matching case retrieval

4 RESEARCH ON RISK PREDICTION AND EARLY WARNING MODEL OF HUMAN RESOURCE MANAGEMENT BASED ON MACHINE LEARNING UNDER ONTOLOGY THEORY

4.1 Risk Prediction and Early Warning Ontology Theory of Human Resource Management Based on Machine Learning

A linear model is a function that uses a linear combination of attributes to make predictions, namely:

$$f(y) = \gamma_1 y_1 + \gamma_2 y_2 + ... + \gamma_k y_k \tag{10}$$

A linear model is an extension of a linear model. The mapping relationship between the independent variable x and the dependent variable y can be nonlinear, but some linear correlation between them can be made through the association function, namely:

$$y = f^{-1}(\gamma^T x + b) \tag{11}$$

where the function $f(y)$ is a monotone differentiable associative function. When $f(y)$ is a logarithmic probability function, the generalized linear model obtained at this time is called the logistic regression model (logarithmic probability regression model), that is:

$$f(y) = \frac{1}{1 + e^{-(\gamma^T x + b)}} \tag{12}$$

Risk prediction and early warning of human resource management is a series of activities related to talent management carried out by enterprises with the goal of enterprise management, including the formulation of human resource strategy, employee recruitment and training and development, performance management, management and health management. The research framework of HR forecasting and early warning is proposed based on ontology technology. It is: Human Body Smart matching research based on HR field. The research on intelligent matching of man-post ontology is based on organizational capability management. The research framework of human resource management forecasting and early warning ontology technology is shown in Fig. 3, which is based on the intelligent matching of human post ontology in recruitment and employment.

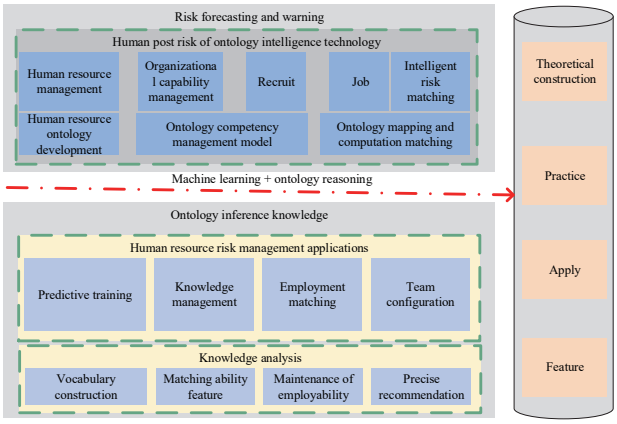

Figure 3 Research framework of human resource management prediction and early warning based on machine learning and ontology

As shown in Fig. 3, Machine learning and ontology, as a research method for human resource management prediction and early warning, combines the changes of economic environment and the risk management of personnel flow. It studies the major decisions and risks in personnel management. Taking employees as an example, decision-making risks in personnel management are mainly manifested in wrong decisions in human resource mobilization, such as transferring excellent employees from the production department to the Marketing Department, believing that employees will have an impact on the new environment, but will have an aversion to the company's management, lose the motivation for work innovation, or the company will lose key employees due to wrong decisions. And employees themselves are affected. Mediocre performance, unable to contribute to the company, affects the future of human resources management and company management. Employees who have a negative impact on the development of the company, this is human resource management.

4.2 Feature Extraction and Data Processing

Employee management forecasting and early warning is affected by a variety of factors, and the selection of characteristics is complex, all features do not need to be considered at the beginning and can be used directly for training. Enterprise factors include salary income, position level, average working hours per day, average overtime hours per day, years of working in the current company, years of working in the current position, and years of service. Among them, salary is the main characteristic factor of employee management forecasting and timely warning, which has a great impact on employee management forecasting and timely warning. Departments and positions that have a significant impact on employee management forecasting and timely warning can reflect the working environment of various departments of the enterprise and the career development of employees. The key factors of employee management forecasting and early warning are the working days and overtime hours of individuals in the company. The years of working in the current company and the years of working in the current position are the employees' familiarity with the current position, which is an important factor in employee management prediction, and can reflect the employees' future development status and promotion opportunities in the company to a certain extent. It is also regarded as one of the characteristics of management forecasting, because taking into account the total number of companies that an employee has worked for may have a certain impact on management warning in the future of an employee's personnel and job matching. Similar data preprocessing operations also need to manage the predicted data characteristics in the previous salary forecast, and the basic data characteristics finally obtained are shown in Tab. 1.

As shown in Fig. 4, the influence of fields such as employees' satisfaction with the company, monthly average working time, performance and working years on the risk prediction and early warning of human resource management, is analyzed in the form of box plot. It can be concluded that the satisfaction of employees with the risk prediction and early warning of human resource management is low, mostly concentrated around 0.4. Human resource management risk prediction and early warning. The average monthly working hours of employees were higher, and most of them exceeded the

average level (201H); Human resource management risk prediction and early warning. The average monthly working time performance assessment of employees is relatively high, most of which is concentrated in 0.8 points or more. The service life of HR risk prediction and early warning is relatively high, generally about 4 years.

Table 1 Data characteristics

Trait	Value
Age	It is a consecutive value, integers 1 to 1000
Pay	Continuous value, real number 0.0-3 0000.0 0
Sex	Discrete values, male and female.
Current residence	Discrete values, including all provinces and cities in the country.
Highest degree	Discrete values, from 1 to 5, 1 the highest grade, where 5 is high school and below, 4 is junior college, 3 is undergraduate, 2 is graduate, and 1 is doctoral.
profession	Enumeration value, high school education or less without a major, including all college majors.
Health status	Enumeration values, including poor, fair, good, and healthy 4.
Marital status	Enumeration value, unmarried, married and divorced 3 kinds.
Department	Enumeration value, including personnel department, finance department, administration department, information center department, product development department, etc
Job grade	Enumeration value, from 1 to 5, 1 indicates the highest level.
Average working hours	Continuous value, real number 0.0-24.0
Years of experience in current position	Continuous values, real numbers 0-60
Total number of companies	The value is a continuous integer ranging from 0 to 60

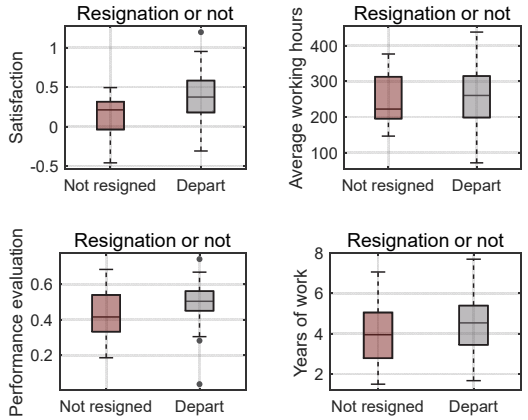

Figure 4 Influence of satisfaction, average monthly working hours, performance and working years on risk prediction and early warning of human resource management

4.3 Machine Learning Model for Human Resource Risk Prediction and Early Warning

As can be seen from the above features and data, in the original data set of salary forecast prediction, some features are non-numerical data (mainly character data), so non-numerical data must be pre-processed by numerical conversion. The value range of some features is too large, which leads to the possibility of numerical problems in training. Therefore, it is necessary to shrink the numerical data with a large interval into a small range, and the target range of the general shrinkage is [0, 1]. Generally, the numeric data obtained after the numeric conversion of character data will have a relatively wide size range, and the range value (that is, the difference between the maximum and the minimum value) will be relatively large, which will easily lead to numerical anomalies and training interruptions in the training process, so the numeric data also needs to be normalized. The normalization formula used here looks like this:

$$y' = \frac{y - y_{\min}}{y_{\max} - y_{\min}} \tag{13}$$

Max and Min are the maximum values in the data set respectively. In the salary prediction model, their formulas are shown as follows. The final prediction results do not belong to the normalized data.

$$y = y'(y_{\max} - y_{\min}) + y_{\min} \tag{14}$$

A human resource management risk prediction and early warning model integrating implicit features is introduced. Nine fields, including satisfaction, average monthly working hours, performance, working years, number of projects involved, promotion within 5 years, salary level, work mistakes and department, are selected as the characteristic value training prediction model in the experiment, and the influence of each field on whether employees leave the company is analyzed. The algorithm flow chart of the model is shown in Fig. 5.

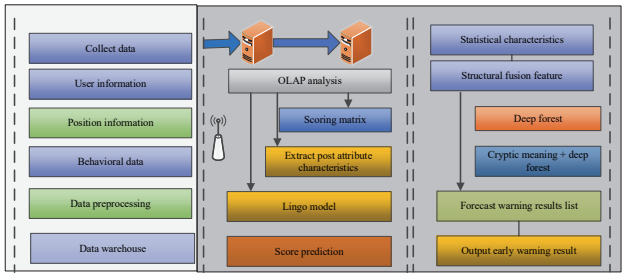

Figure 5 Overall flow chart of the algorithm

Table 2 Human resource management risk prediction and early warning algorithm based on machine learning

Input:
Behavioral data
User information
Position information
Output:
Management risk prediction and early warning results
Steps:
1. Implement data pre-management according to the problems existing in the input original data.
2. Build HR data stack
3. Introduce coordination implicit skills to make OLAP judgment based on data stack.
4. Establish a masking semantic model based on user actions, and introduce a linear LR model into the cascade forest organization.
5. Complete the unification of the implicit characteristics of deep forests
6. Implementation of mixed governance forecasting and early warning
7. Management risk outlook and early warning result output

As can be seen from the overall process of the algorithm in Fig. 5, the risk prediction and early warning algorithm of human resource management based on

machine learning takes user information and behavioral data as the input of the overall algorithm, makes full use of the collected personal information of job seekers and the historical behavioral information of users such as browsing, collecting and applying, and finally outputs the result of job management risk prediction and early warning. Algorithm Tab. 2 shows the specific algorithm description.

5 SIMULATION VERIFICATION

The machine learning model was used for risk prediction, and the activation function was root-mean-square error. At the same time, the small-lot gradient descent method and hybrid optimization method NADM were used to update the network parameters. The evaluation method adopted in this experiment is the leave-one-out method. The data set with sample space of 1100 is divided into two subsets, 2000 and 200. The 2000-size subset is used as the training set, and the 200-size subset is used as the test set.

Their updates during the actual training of the model are given here, as shown in Fig. 6, to compare the training effects of various optimization algorithms of machine learning. As can be seen from Fig. 5, hybrid optimization algorithms Adam and Nadam perform better than other optimization algorithms in terms of convergence speed, while Nadm performs slightly better than Adam in terms of overall performance.

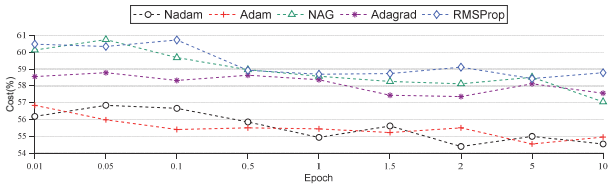

Figure 6 Comparison of convergence speed of various optimization methods

Their comparative training results are given here, as shown in Tab. 3, in order to better compare the performance of various optimization algorithms. Among them, the training sample space size adopted in Tab. 3 is 2000, the test sample space size is 200, and the training is stopped when the period (EPOCH reaches 20000 or $E < 0.01$).

Table 3 Training results of various optimization algorithms

Optimization algorithm	Test score	Cycle	Training loss
SGD(Stochastic Gradient Descent)	0.7324	3228	0.00482
Momentum	0.7323	1617	0.00481
NAG(Nesterov Accelerated Gradient)	0.7315	1543	0.00485
Adagrad	0.7482	1023	0.00483
RMSProp	0.7486	223	0.00480
Adam	0.7503	195	0.00491
Nadm	0.7512	186	0.00498

In order to better reflect the performance of NADM human resource management risk prediction model, the comparison results with other machine learning regression algorithms are presented here, as shown in Tab. 4. Among them, the human resource management risk prediction model in Tab. 4 adopts 2000 training sample Spaces and 200 test sample Spaces. Each algorithm conducts 20 experiments respectively to obtain the optimal test results. It can be seen that the human resource management risk prediction model optimized by Nadm has a relatively good score on the test set compared with other algorithms. Finally, the Nadm human resource management risk prediction model for predicting the fitting effect is given, and the fitting diagram of experimental results is shown in Fig. 7.

Table 4 Comparison of regression prediction algorithms for human resource management risk prediction and early warning

Algorithm	Training score	Test score
Nadm	0.77321	0.77432
Linear	0.77482	0.76254
Polynomial	0.81342	0.73931
idge	0.74562	0.71474
Lasso	0.74416	0.72843
ElasticNet	0.75623	0.73256

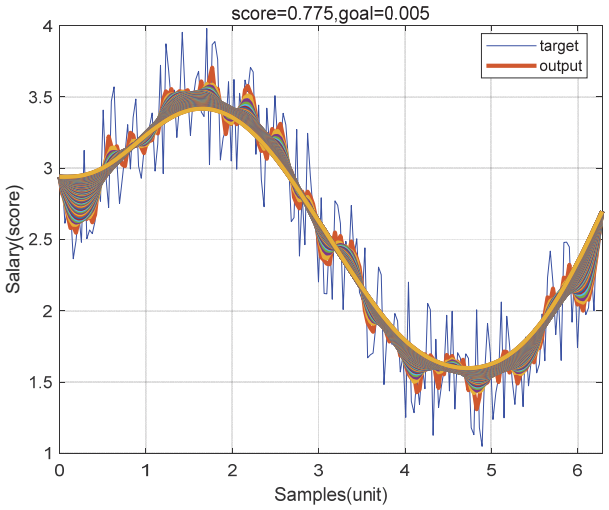

Figure 7 Fitting effect of Nadam human resource management risk prediction and early warning prediction model

As can be seen from Fig. 7, the prediction fitting effect of HR risk prediction is relatively good. Although HR risk prediction and early warning data are normalized during model training, some errors may be caused during calculation, but are still within the controllable range and have little impact on the final result of the model.

The HR machine learning risk prediction and early warning model proposed in this paper integrates implicit features by designing the fusion features of a user's certain post as the initial input of the HR machine learning risk prediction and early warning model, rather than the explicit features of the user-post. The fused features not only consider the structural basic attribute features and statistical features obtained through OLAP analysis users who pull a position directly from the HR data warehouse, but also consider the hidden features mined from the user behavior data, which adds more information to the model and reduces the impact of losing some users or job attributes on the model. The machine learning risk prediction and early warning model input is compared before and after the introduction of implicit features, and the experimental results are shown in Fig. 8 to test whether the fused features improve the model performance.

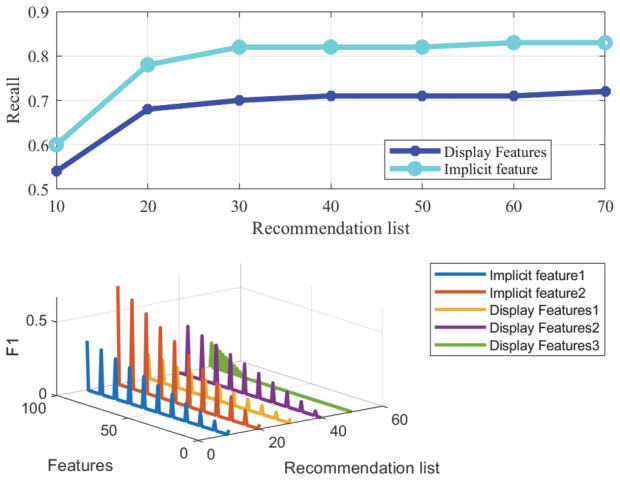

Figure 8 Comparison before and after the introduction of implicit features

Considering that cascaded forest-based classifiers have something in common with tree algorithms, in addition to the input features of deep forests, the algorithm also introduces a linear LR model as a base classifier in the cascaded forest structure, making the differences of each model possible to change. Here, the models before and after the introduction of LR are compared to verify the effectiveness of the linear classifier in improving the classification performance of the cascade structure. The experimental results are shown in Fig. 9.

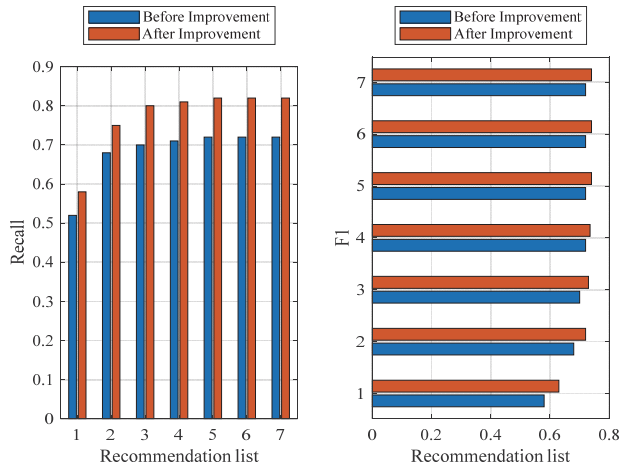

Figure 9 Comparison before and after model improvement

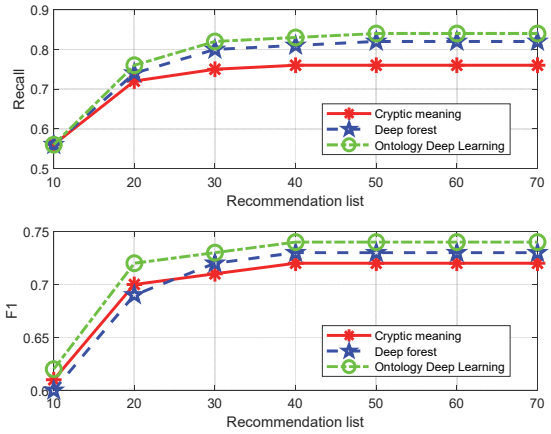

Figure 10 Comparison between hybrid machine learning human resource risk prediction and early warning model and single model

In order to test whether the performance of the hybrid recommendation algorithm is better than that of the single recommendation algorithm, we analyze and compare the performance of HR risk prediction and early warning, DeepForest and HR risk prediction and early warning algorithms based on the potential semantic model. The experimental results are shown in Fig. 10.

From the experimental results shown above, it can be seen that the hybrid machine learning HR risk prediction and early warning model algorithm is superior to the single cryptic model and deep forest in terms of recall rate and FL value, and the recall rate reaches 82%, indicating that the hybrid machine learning HR risk prediction and early warning model algorithm integrate the advantages of the two models, the machine learning human resource risk prediction and early warning model are better integrated, and the performance of volume algorithm is improved. Among them, the performance of deep forest is better than that of implicit meaning model indicating that the content characteristics of users and posts can affect the HR risk prediction and early warning model more than the user behavior in the field of HR machine learning HR risk prediction and early warning model, which is consistent with the reality that users are more focused on combining their own conditions and job requirements. The $F1$ value curve of HybridMachineHR risk prediction and early warning model algorithm is close to deep forest, which means that the performance of the algorithm's comprehensive machine learning HR risk prediction and early warning model is close to deep forest, and its advantage is smaller than that of the cryptic model, indicating that the contribution of deep forest to the final performance of the hybrid algorithm is greater than that of the cryptic model HybridMachineHR risk prediction and early warning model plays a major role, and the cryptic model is the algorithm that complements the HybridMachineHR risk prediction and early warning model.

The risk prediction and early warning algorithm of human resource management based on implicit semantic model and deep forest proposed in this paper is to mix the implicit semantic model and deep forest, and comprehensively consider two aspects of user interest and job matching to predict. The realization of human resource risk early warning and implicit characteristics improves the inaccurate human resource risk prediction and early warning caused by the lack of explicit characteristics of user posts to a certain extent. By introducing implicit features, the performance of other human resource risk prediction and early warning algorithms can be tested and compared with algorithms based on hidden semantic models. This paper selects three most representative HR risk prediction and early warning algorithms. Early warning algorithms and early warning algorithms in HR risk prediction - based on users. Let's compare this with project-based collaborative filtering and content-based HR risk prediction and early warning algorithms, as shown in Fig. 11.

It can be seen from Fig. 11 that the human resource management risk prediction and early warning algorithm based on cryptic meaning model and deep forest is superior to collaborative filtering (including UserCF and content-based human resource management risk prediction and

early warning algorithm). Both the recall rate and *F*1 value of human resource management risk prediction and early warning indicate the overall human resource management risk prediction and early warning of the proposed algorithm. The performance is better than the traditional human resource management risk forecasting and early warning method.

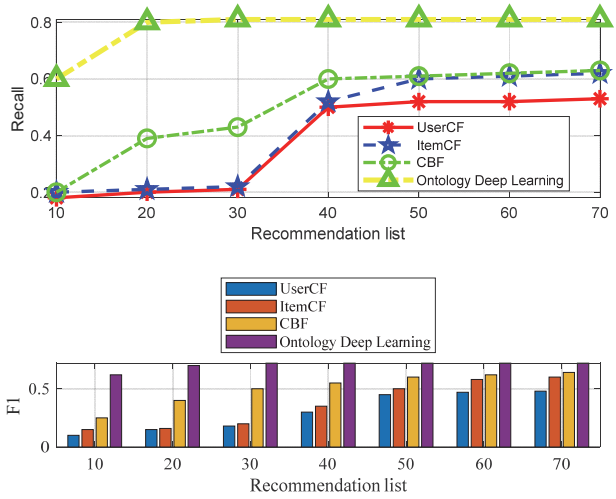

Figure 11 Comparison of different risk prediction and early warning algorithms of human resource management

The second type of words and the sixth type of words after machine learning are merged into the document frequency matrix, and all the repeated combined human resource management risk factors are sorted according to the frequency of occurrence. At the same time, according to the frequency, the word cloud map with more than 300 frequencies is selected from top to bottom, as shown in Fig. 12.

Figure 12 Cloud map of human resource management risk prediction and early warning words

6 CONCLUSION

Traditional HR risk prediction cannot effectively analyze the existing data, nor can it predict the future development based on the existing data. By applying machine learning technology to human resource management risk prediction, the human resource management risk prediction and early warning model is realized to improve the practicability of human resource management risk prediction. It mainly researches ontology reasoning and machine learning human resource analysis and prediction methods. It adopts machine learning algorithms such as Nadm, Linear, Polynomial, Idge, Lasso, ElasticNet and DeepForest to conduct data set training for classification models and conduct comparative analysis on evaluation results of each model. The optimal model is obtained and applied to human resource analysis and prediction. The research shows that the HR analysis and prediction method based on the crypto-meaning model and DeepForest has achieved excellent results. It can provide effective reference information for the company, facilitate the manager to understand the psychological dynamics of employees, and reduce the impact of HR risk prediction and early warning on the company's profits, which has certain practical value and practical significance. The next step will be to consider the implementation of parallelization of the proposed recommendation algorithm. In the follow-up work, the implementation of parallelization of the algorithm can be studied, so as to improve the efficiency of model training. In the future work, how to recommend suitable talents to enterprises and carry out two-way recommendation of human resources can be further studied, so as to achieve a win-win situation between job seekers and enterprises.

7 REFERENCES

[1] Zeng, H. (2021). Research on Risk Measurement and Early Warning of Electronic Banking Business Based on GMDH Algorithm. *Security and Communication Networks*, *2021*(1), 51-59. https://doi.org/10.1155/2021/2678161

[2] Wei, G. J. Y. (2021). Human resource management model based on three-layer BP neural network and machine learning. *Journal of intelligent & fuzzy systems: Applications in Engineering and Technology*, *40*(2), 723-734. https://doi.org/1010.3233/JIFS-189226

[3] Akbarian, H., Gheibi, M., & Hajiaghaei-Keshteli, M. (2022). A hybrid novel framework for flood disaster risk control in developing countries based on smart prediction systems and prioritized scenarios. *Journal of Environmental Management*, *2022*(312), 312-324. https://doi.org/1010.1016/j.jenvman.2022.114939

[4] Yuan, S., Kroon, B., & Kramer, A. (2021). Building prediction models with grouped data: A case study on the prediction of turnover intention. *Human Resource Management Journal*, *1748*, 12396-12408. https://doi.org/1010.1111/1748-8583.12396

[5] Kang, I. G., Kim, N., & Loh, W. Y. (2021). A Machine-Learning Classification Tree Model of Perceived Organizational Performance in U.S. Federal Government Health Agencies. *Sustainability*, *13*, 10329-10338. https://doi.org/1010.3390/su131810329

[6] Zhu, G. S. B. (2019). A comprehensive literature review of the demand forecasting methods of emergency resources from the perspective of artificial intelligence. *Natural Hazards*, *97*(1), 63-78. https://doi.org/1010.1007/s11069-019-03626-z

[7] Li, W. (2021). Research on Project Knowledge Management Risk Early Warning Based on Bp Neural Network. *Journal of Physics Conference Series*, *1744*(3), 32250-32259. https://doi.org/1010.1007/s11069-019-03626-z

[8] Zhao, J., Yu, J., & Wang, X. (2020). Research on Systematic Risk Early Warning System Based on Machine Learning Technology: A Case Study of Marine Economy. *Journal of Coastal Research*, *108*(sp1), 451-465. https://doi.org/1010.2112/JCR-SI108-045.1

[9] Wang, X. T. (2019). Research on Default Prediction of

Online Lending Borrowers Based on Machine Learning. *Service Science and Management*, *8*(1), 40-48. https://doi.org/1010.12677/SSEM.2019.81006
[10] Liu, J. (2021). Impact of enterprise human capital on technological innovation based on machine learning and SVM algorithm. *Journal of Ambient Intelligence and Humanized Computing*, *2021*(11), 3045-3053. https://doi.org/1010.1007/s12652-021-03045-8
[11] Liu, S. (2021). Human Resource Management of Internet Enterprises Based on Big Data Mobile Information System. *Mobile Information Systems*, *2021*(5), 121-129. https://doi.org/1010.1155/2021/1549342
[12] Gong, Y., Zhao, M., & Wang, Q. (2022). Design and interactive performance of human resource management system based on artificial intelligence. *PloS one*, *17*(1), 262398-262408. https://doi.org/1010.1371/journal.pone.0262398
[13] Wang, C., Sha, Z., & Jia, L. (2021). Research on Digital Resource System Construction of Smart Library Based on Computer Network and Artificial Intelligence. *Journal of Physics: Conference Series*, *1952*(4), 42018-42032. https://doi.org/1010.1088/1742-6596/1952/4/042018
[14] Mallick, A. (2021). Application of Machine Learning (ML) in Human Resource Management. *Springer Books*, *10*(3), 7-12. https://doi.org/1010.26438/ijcse/v5i12.173180
[15] Singer, G. & Cohen, I. (2020). An Objective-Based Entropy Approach for Interpretable Decision Tree Models in Support of Human Resource Management: The Case of Absenteeism at Work. *Entropy*, *22*(8), 821-835. https://doi.org/1010.3390/e22080821
[16] Jain, P. K., Jain, M., & Pamula, R. (2020). Explaining and predicting employees' attrition: a machine learning approach. *SN Applied Sciences*, *2*(4), 2519-2523. https://doi.org/1010.48550/arXiv.2202.01765
[17] Achchab, S. & Temsamani, Y. K. (2022). Use of Artificial Intelligence in Human Resource Management: "Application of Machine Learning Algorithms to an Intelligent Recruitment System". *Entropy*, *9*(3), 365-370. https://doi.org/1010.1007/978-3-030-85365-5_20
[18] Qi, L. & Yao, K. (2021). Artificial Intelligence Enterprise Human Resource Management System Based on FPGA High Performance Computer Hardware. *Microprocessors and Microsystems*, *82*(3), 3876-3887. https://10.1016/j.micpro.2021.103876
[19] Choi, Y. & Choi, J. W. (2021). The Prediction of Workplace Turnover Using Machine Learning Technique. *International Journal of Business Analytics*, *2021*(4), 8-21. https://doi.org/1010.1016/j.chb.2021.107029
[20] Kock, F. S. D., Lievens, F., & Born, M. P. (2020). The profile of the 'Good Judge' in HRM: A systematic review and agenda for future research. *Human Resource Management Review*, *30*, 1-21. https://doi.org/1010.1016/j.hrmr.2018.09.003
[21] Mulrow, J., Kshetry, N., & Brose, D. A. (2019). Prediction of Odor Complaints at a Large Composite Reservoir in a Highly Urbanized Area: A Machine Learning Approach. *Water Environment Research*, *92*(1), 1191-1205. https://doi.org/1010.1002/wer.1191
[22] Wei, G. & Jin, Y. (2021). Human resource management model based on three-layer BP neural network and machine learning. *Journal of Intelligent and Fuzzy Systems*, *40*(2), 2289-2300. https://doi.org/1010.3233/JIFS-189226
[23] Lu, C., Teng, Z., & Gao, Y. (2021). Analysis of Early Warning of RMB Exchange Rate Fluctuation and Value at Risk Measurement Based on Deep Learning. *Computational Economics*, *21*(10), 10172-10193. https://doi.org/1010.1007/s10614-021-10172-z
[24] Yamaguchi, M., Kitazawa, S., & Kaneko, T. (2019). Risk potential estimation for autonomous vehicles based on risk-prediction of human driver in low-infrastructure city roads. *The Proceedings of the Transportation and Logistics Conference*, *28*(2), 3102-3121. https://doi.org/1010.1299/jsmetld.2019.28.3102
[25] Ying, L., Jia, Y., & Li, W. (2020). Research on State Evaluation and Risk Assessment for Relay Protection System Based on Machine Learning Algorithm. *IET Generation Transmission & Distribution*, *14*(18), 6552-6565. https://doi.org/1010.1049/iet-gtd.2018.6552
[26] Yuan, H., Zhang, Z., & Yuan, P. (2020). A microgrid alarm processing method based on equipment fault prediction and improved support vector machine learning. *Journal of Physics: Conference Series*, *1639*(1), 12041-12048. https://doi.org/1010.1088/1757-899X/90/1/012081
[27] Xiaorong, G. & Yingzhuo, X. (2019). Research on Lost Circulation Risk Intelligent Identification and Processing System Based on CBR. *Journal of Physics: Conference Series*, *1237*, 42025-42042. https://doi.org/1010.4018/IJAPUC.2016040103
[28] Liu, S., Dang, Y., & Li, R. (2022). Research on on-line monitoring data cleaning of transformer oil chromatogram based on machine learning and neural networks. *IOP Publishing Ltd*, *8*, 2271-2289. https://doi.org/1010.1088/1742-6596/2271/1/012027
[29] Li, X. & Geng, S. (2021). Research on fuzzy English automatic recognition and human-computer interaction based on machine learning. *Journal of Intelligent & Fuzzy Systems: Applications in Engineering and Technology*, *2021*(5), 41-52. https://doi.org/1010.3233/JIFS-189057
[30] Mao, Z., Zheng, T., & Lian, Z. (2021). Information System Construction and Research on Preference of Model by Multi-Class Decision Tree Regression. *Journal of Physics: Conference Series*, *1982*(1), 12153-12160. https://doi.org/1010.1088/1742-6596/1982/1/012153
[31] Li, C., Meng, Z., & Chang, L. (2021). Financial Risk Analysis and Early Warning Research Based on Data Mining and Statistical Analysis Technology. *Journal of Physics: Conference Series*, *2136*(1), 12063-12074. https://doi.org/1010.4028/www.scientific.net/AMM.513-517.1940
[32] Du, C., Bing, B., & Mao, X. (2020). Research on Automatic Monitoring and Early Warning System Based on BIM Smart Infrastructure Risk. *IOP Conference Series Earth and Environmental Science*, *455*, 12197-12206. https://doi.org/1010.1088/1755-1315/455/1/012197

Contact information:

Miaomiao TANG
(Corresponding author)
Hubei Open University,
Hubei Science and Technology College,
Wuhan, 430074, China
E-mail: tangmiaomiao@hubstc.edu.cn

Tianwu ZHAO
Hubei Open University,
Hubei Science and Technology College,
Wuhan, 430074, China

Zhongdan HU
Department of Civil Affairs of Hubei Province,
Wuhan, 430079, China

Qinghua LI
College of Economics and Management,
Yantai Nanshan University,
Yantai, 265713, China