A Bilateral Matching Management Method for Intelligent Workgroups Considering the Balance of Personnel and Positions

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Abstract. In order to solve the bilateral matching problem of digital person-post in the intelligent team, a bilateral matching model between personnel and positions considering the balance of overall and individual satisfaction has been proposed. Firstly, the preference order of employees and posts is calculated based on the principle of object element through the mutual evaluation between employees and posts. From the perspective of both enterprises and employees, considering the individual differences in satisfaction among employees. The optimization objective is to maximize the overall satisfaction and minimize the variance of individual satisfaction, the constraints are the maximum number of individual matches and the worst match limit. Following that, the NSGA-II algorithm is applied to solve the problem, and the chromosome is coded in two-dimensional 0-1. The Pareto front solution set of (0.24,0.28) is taken as the example of the shift management platform information of a company in the State Grid, and it is verified that the matching solution satisfying the overall and individual satisfaction balance can be obtained by the method of this paper. The matching model of this paper is implemented in the digital job matching function of the platform, which can provide the job manager with a matching solution that satisfies both sides.

Keywords: bilateral matching; person-post management; preference order; multi-objective optimization; improved NSGA-II algorithm

1 Introduction

With the continuous improvement of standardized job management requirements in modern enterprises, intelligent job management platforms have gradually become an important part of modern management technology in enterprises. Establishing standardized, reasonable, and fair job matching standards can promote employees' work initiative, enhance the attractiveness and competitiveness of the enterprise, and bring more stable development to the enterprise.

The existing research on person job matching mostly measures the degree of person job matching by calculating similarity, and common methods include cosine similarity calculation,

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Euclidean distance calculation, etc. Alberto et al. [1] analyzed the personal information of job seekers in job recommendation platforms and determined their preferences, proposing a career work feedback mechanism that infers and makes final decisions based on historical case experiences. Chen Mengting et al. [2] designed an internship position recommendation algorithm for graduates, vectorized the feature attributes between graduates and positions, and used cosine similarity for difference calculation. Reusens et al. [3] proposed a user collaborative filtering system based entirely on implicit feedback data, evaluating which data types best indicate job seekers' job interests. Many scholars have conducted extensive research on human job matching methods, but most of them have simply calculated and summarized the characteristics of human job matching based on historical data [4-6]. The above research mainly focuses on qualitative analysis and mostly focuses on one-way job recommendations for employees or users. The two-way analysis between people and positions is relatively rough, making it difficult to apply to actual enterprise personnel and job management.

The research and application of bilateral matching theory was first proposed by Gale and Shapley in a groundbreaking paper in 1962 [7]. In recent years, this theory has rapidly developed in the study of matching problems in various industries. Gimbert et al. [8] studied the classic combinatorial problem of stable matching between men and women, guiding each participant to evaluate their opposite gender participants, using the ranking of preferences as input to the model, and analyzing the impact of relevant variables on the approximate operability of stable matching algorithms. Tang Jiajun et al. [9] proposed a model solving method based on entropy weight analytic hierarchy process based on Gale Shapley algorithm to analyze the matching between virtual power plants and distributed resources. Li Yingxin et al. [10] studied the matching of design tasks and knowledge resources, established a matching framework for cloud manufacturing patterns, and validated the quality of this method using product development process knowledge as an example. Liu et al. [11] considered the resource matching problem between students and projects, classified them into different types based on their preferences, and developed a strategy proof mechanism to meet the requirements of fairness and efficiency. However, there are few existing studies on human job bilateral matching, and most of them are based on basic calculations, and the impact of matching results on individual matching satisfaction is rarely considered.

In summary, this article conducts research on management platforms based on the bilateral matching theory, taking into account the overall satisfaction of enterprises and individual employee satisfaction, in order to make it more in line with the actual work situation, provide more scientific and objective evaluation references to management, help enterprises organize and manage human resources more effectively, and improve employee satisfaction and work efficiency.

2 Matching Algorithm Design

2.1 Preference Order Based on Matter Element Principle

Before solving the bilateral matching algorithm, it is necessary to first process the data of the evaluation index scores of both employees and positions to obtain the preference order of each other. Based on the matter-element principle, construct and establish a fuzzy matter-element matrix Rmn for the evaluation of human job bilateral matching:

$$R_{mn}=\begin{bmatrix} & M_1 & M_2 & \cdots & M_n \\ C_1 & u_{11} & u_{12} & \cdots & u_{1n} \\ C_2 & u_{21} & u_{22} & \cdots & u_{2n} \\ \vdots & & & & \\ C_m & u_{m1} & u_{m2} & \cdots & u_{mn} \end{bmatrix} \quad (1)$$

where u_{ij} represents the evaluation value of employees (positions) to positions (employees) under various evaluation indicators C_j.

According to the normalization principle of the maximum minimum operator, the fuzzy matter element matrix $\overline{R}_{mn}$ is obtained, and the standard deviation square composite fuzzy matter element matrix R_Δ is obtained based on $\Delta_{ij}=\left(1\text{-}U_{ij}\right)^2$:

$$R_\Delta=\begin{bmatrix} & M_1 & M_2 & \cdots & M_n \\ C_1 & \Delta_{11} & \Delta_{12} & \cdots & \Delta_{1n} \\ C_2 & \Delta_{21} & \Delta_{22} & \cdots & \Delta_{2n} \\ \vdots & & & & \\ C_m & \Delta_{m1} & \Delta_{m2} & \cdots & \Delta_{mn} \end{bmatrix} \quad (2)$$

Determine the entropy of evaluation indicators:

$$H_j=-\frac{1}{\text{In}\, m}\left(\sum_{i=1}^{m} f_{ij}\,\text{In}\, f_{ij}\right) \quad (3)$$

where $f_{ij}=\left(1+\Delta_{ij}\right)\Big/\sum_{j=1}^{n}\left(1+\Delta_{ij}\right)$.

The calculation formula for the weight Wj of various evaluation indicators is:

$$W_j=\frac{1-H_j}{\sum_{j=1}^{n}\left(1-H_j\right)} \quad (4)$$

The preference order uses closeness as the basis, and the higher the closeness value, the higher the correlation degree, and the higher the preference order. Select the Euclidean distance to calculate closeness, and the calculation formula is:

$$R_{PH}=\begin{bmatrix} & N_1 & N_2 & \cdots & N_m \\ PH & PH_1 & PH_2 & \cdots & PH_m \end{bmatrix} \quad (5)$$

where $PH_i=1-\sqrt{\sum_{j=1}^{n} W_j\Delta_{ij}}\ \left(i=1,2,\cdots\cdots,m\right)$.

2.2 Construction of Bilateral Matching Model

To achieve a bidirectional matching mechanism between personnel and positions, a bilateral matching model was designed as shown in Figure 1. The weight of the directed line between A_i and B_j in Figure 1 represents the preference order size of the supply and demand sides, and the undirected thick line between A_i and B_j represents the matching between A_i and B_j.

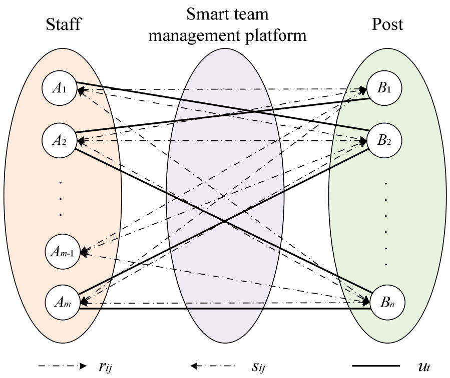

Fig.1 Two-sided matching decision problem

Set the employee set as $A= \{A_1, A_2, \cdots, A_m\}$, where A_i represents the i-th employee, i=1, 2, ⋯, m. The position set is $B= \{B_1, B_2, \cdots, B_n\}$, where B_j represents the j-th position, j=1,2, ⋯, n. Let $R= \{R_1, R_2, \cdots, R_m\}$ be the preference order vector given by employee A_i regarding position B, and employee A_i places position B_j at r_{ij}. Let $S= \{S_1, S_2, \cdots, S_m\}$ be the preference vector for employee A given by position B_j, where position B_j places employee A_i at s_{ij}.

(1) Maximum overall satisfaction

After getting the preference order use it to calculate the satisfaction value, let α_{ij} be the satisfaction value of the i-th employee A_i to the j-th position B_j, β_{ij} be the satisfaction value of the j-th position B_j to the i-th employee A_i. In reality, the preference order is not linearly related to the satisfaction, such as the employee's satisfaction gap between the first and the second position in the order will be much larger than the satisfaction gap between the penultimate and the penultimate position, so the expression of α_{ij} and β_{ij} is defined as

$$\alpha_{ij} = \frac{1}{r_{ij}}, \qquad (6)$$

$$\beta_{ij} = \frac{1}{s_{ij}}, \qquad (7)$$

where r_{ij} and s_{ij} respectively represent the corresponding preference ranking of both parties, that is, the reciprocal of the preference order of both parties is defined as the satisfaction of both parties.

To construct an optimization model and code it for solution, a 0-1 decision variable x_{ij} is introduced, where x_{ij} is 1 indicating a match between the i-th employee and the j-th position, and 0 indicating a mismatch. The overall satisfaction optimization model for both employees and positions is

$$\max Z_1 = \sum_{i=1}^{m} \sum_{j=1}^{n} \alpha_{ij} x_{ij} \qquad (8)$$

$$\max Z_2 = \sum_{i=1}^{m}\sum_{j=1}^{n}\beta_{ij}x_{ij} \qquad (9)$$

Objective Z_1 represents maximizing the overall satisfaction of employee subject A about the matching of job subject B. Objective Z_2 represents maximizing the overall satisfaction of job subject B about the matching of employee subject A. Setting up Z_1 and Z_2 for the set counting process to get the overall satisfaction total objective Z_3, the model is expressed as follows

$$\max Z_3 = \eta_1\sum_{i=1}^{m}\sum_{j=1}^{n}\alpha_{ij}x_{ij} + \eta_2\sum_{i=1}^{m}\sum_{j=1}^{n}\beta_{ij}x_{ij} \qquad (10)$$

where: η_1 and η_2 are weighting coefficients, both of which are taken as 0.5 in this paper, and the proportion of η_2 can be increased appropriately if the job manager pays more attention to the satisfaction of the job side.

(2) Individual employee satisfaction variance minimization

In order to avoid the occurrence of large satisfaction gap and negative psychology of each employee in the matching to the post, the establishment of individual employee satisfaction variance optimization model, which is expressed as

$$\min Z_4 = \frac{\sum_i\left(\sum_j\alpha_{ij}x_{ij} - f_A\right)^2}{\sum_i\sum_j x_{ij}} \qquad (11)$$

where $f_A = \left(\sum_i\sum_j\alpha_{ij}x_{ij}\right)/m$ is the average value of employees' individual satisfaction.

2.3 Bilateral matching model solution

The bilateral matching model of this paper is a nonlinear 0-1 planning model, which can be solved by heuristic algorithm. In this paper, NSGA-II algorithm is used and improved, the specific solution steps are as follows:

Step 1: Information input, bilateral satisfaction ranking calculation.

By the employees and job managers respectively demand information input, the platform establishes the mutual evaluation index set *C* and *D* of the employees and jobs respectively. based on the satisfaction ranking method described in section 2.1, the calculation is carried out, and the satisfaction ranking table of the two sides is obtained.

Step 2: Chromosome coding.

The chromosome individuals in this paper take two-dimensional 0-1 coding, and establish the coding matrix E with total length m × n. m and n represent the total number of employees and positions that need to be matched, respectively. The 0-1 in the coloring is the value of xij taken in the objective function.

Step 3: Adaptation Calculation.

The fitness calculation process selects the inverse of Eq. 10 and Eq. 11 as the objective function so that the expectation of both is minimized.

Step 4: Population evolution strategy.

The population constructed in this paper should not only consider the two-dimensional characteristics of individuals in the evolution process, but also timely check whether the individuals meet the constraints, and adjust the individuals that do not meet the constraints, so the programming design of the crossover and variation operators suitable for the model in this paper.

2.4 Calculation example analysis

The shift management platform of a company in the State Grid receives job managers to enter (B_1, B_2, B_3, B_4, B_5) five in-demand job information in the platform, and it is proposed to arrange appointments among (A_1, A_2, A_3, A_4, A_5, A_6) six candidate employees.

Employee's evaluation index set C= {C_1, C_2, C_3, C_4}, C_1, C_2, C_3, C_4 represent the salary offered by the position, the working environment score, the degree of professional counterpart and the vacation system score, respectively. the evaluation index set D= {D_1, D_2, D_3, D_4}, D_1, D_2, D_3, D_4 represent the employee's expected salary, the academic degree and the grade certificate score, respectively, professional counterpart degree and work experience score. The evaluation ranking table of both parties calculated by the method in section 2.1 is shown in Table 1 and Table 2.

Tab.1 Ranking of positions *B* by employees *A*

Staff	*B*1	*B*2	*B*3	*B*4	*B*5
*A*1	1	3	2	5	4
*A*2	5	4	3	2	1
*A*3	5	3	4	2	1
*A*4	3	5	2	4	1
*A*5	5	3	4	1	2
*A*6	4	2	1	3	5

Tab.2 Ranking of employees *A* by positions *B*

Post	*A*1	*A*2	*A*3	*A*4	*A*5	*A*6
*B*1	5	1	6	4	2	3
*B*2	6	2	5	1	4	3
*B*3	5	6	4	3	2	1
*B*4	3	2	6	5	1	4
*B*5	5	3	2	6	1	4

Let the maximum number of jobs limiting employees' choices be 4, 1, 2, 2, 2, 2, and 3, respectively, and the jobs expect to get the maximum number of employee matches that can be chosen as 2, 1, 3, 2, and 2. A matching scheme can be obtained with an individual employee satisfaction variance threshold of 0.3 and an acceptable solution (0.24,0.28) for both employees and positions. The matching relationship is shown in Figure 1, and position managers can refer to this matching relationship to determine the final personnel appointment scheme.

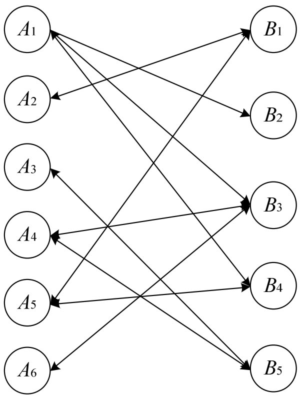

Fig.2 Matching relationship under acceptable solutions (0.24,0.28) for person-post

From Figure 2, it can be seen that employee A_1 can be qualified for the three positions of B_2, B_3 and B_4, and for the position of B_1, it can be selected among the two employees of A_2 and A_6. Individual satisfaction variance under this matching relationship is small, indicating that the differences between individuals are small, and the inverse of the overall satisfaction is small, the overall satisfaction is high, to meet the satisfaction needs of both parties.

3 Conclusion

This paper analyzes the demand relationship between personnel and positions, gets the preference order of personnel and positions based on the principle of object element, and designs the bilateral matching model considering the equilibrium of personnel and positions. The contributions of this paper mainly include: 1) proposing that while optimizing the satisfaction of the enterprise, the satisfaction differences of the employees should be considered, and constructing two objective functions, namely, the maximum overall satisfaction and the minimum variance of individual satisfaction. 2) establishing a two-dimensional coding matrix for this nonlinear 0-1 planning model, and solving it with NSGA-II algorithm. Taking the information of the shift management platform of a company of the State Grid as a case study, the Pareto frontier solution obtained by the algorithm is analyzed and the results of the algorithm are taken into consideration of the enterprise as a whole and the individual employees at the same time, so as to provide valuable reference solutions for the post managers. after the algorithm is verified, the software design of the platform is carried out and the performance test is conducted, so as to realize the intelligent shift personnel and post management platform. The next step of the research will focus on further exploring the individual differentiation and stable matching of the priorities of the two parties, in order to improve the practicality and adaptability of the model.

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