The Cultivation Quality Evaluation of International Talents Based on Deep Learning

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Abstract—The average quality of Chinese talents, especially international talents, is falling behind the international level. For the introduction of high-level international talents, the evaluation of the cultivation quality of high-level international talents is an important factor, and this work is a basis of the said matter. However, most of the existing works related to this topic are just about the definitions of high-level international talents, their features, and importance, or discussions of other aspects. This paper aims to study the evaluation of the cultivation quality of international talents based on deep learning. At first, the paper gave a framework for the ideas of international talent cultivation, established an Evaluation Index System (EIS) containing 4 basic elements for such evaluation, and emphasized the importance of the training and testing of professional business English. At first, the paper gave a framework for the ideas of international talent cultivation, and established an Evaluation Index System (EIS) containing 4 basic elements for such evaluation. Then, this paper proposed the evaluation flow, and adopted an Empirical Mode Decomposition (EMD) algorithm to the analysis of the quality change during the cultivation process of international talents. After that, for the change trend of the cultivation quality of international talents at different time scales, this paper applied a Long Short Term Memory (LSTM) network for training and obtained the corresponding predicted quality value. At last, experimental results verified the effectiveness of the proposed model in predicting the cultivation quality evaluation of international talents.

Keywords—deep learning, international talents, cultivation quality evaluation

1 Introduction

In the study of modern management, the quality requirement of high-level talents has always been a research hotspot [1-6]. The average quality of Chinese talents, especially international talents, is falling behind the international level [7-11]. For the foreign trade industry which is particularly important for China, if we want to effectively change its development mode and improve the applicability of high-level international talents in this industry, the first thing to do is to make efforts to increase the proportion of high-level international talents [12-18]. By analyzing the foreign trade business or other jobs that high-level international talents are engaged in, it's found that the evaluation of the cultivation quality of high-level international talents from a practical point of view is an important factor and a basic work for the introduction of these talents.

In this era of global informatization, knowledge economy is developing at a fast pace, and international business operation has become a crucial means for enterprises to allocate core resources and win competitive advantages. Wang and Dong [19] pointed out in their research that multinational enterprises can get various resources such as knowledge, technology and relationship via the localization of international talents, then they can overcome the difficulties they encounter in the host countries in aspects of culture, sales, and management, thereby creating conditions and laying basis for their sustainable development and becoming bigger and stronger in the future. Zhu et al. [20] discussed the international strategies of colleges and universities, such as the send-out strategy, the join-in strategy, and the acceptance strategy, etc., then for a few unsolved problems, such as excessive commercialization, insufficient government financial support, bad culture erosion, and blind imitation, they proposed corresponding countermeasures, which had provided some references for the country to cultivate more international talents. Beaverstock [21] discovered a new theoretical and empirical perspective to study the reproduction of elites in multinational enterprises through the process of talent mobilization within the firm, rather than the process of personnel dispatch; then, by creatively contacting the inter-language between global talents, multinational elites, and labor markets, this study increased the understanding of the reproduction of elites in multinational enterprises. Benham [22] proposed that with the expansion of overseas chemical manufacturing outsourcing business, the competition between domestic institutions and overseas competitors has becoming increasingly fierce, the funds received by domestic research institutions and the investment in infrastructure construction have decreased, which poses great challenges to the country in creating new opportunities to maintain its global competition advantages.

Few existing studies have concerned about the evaluation of the cultivation quality of this special group, the high-level international talents. Though some have looked into this group, most of them are just about the definitions of high-level international talents, their features, and importance, or discussions of other aspects. The evaluation of the cultivation quality of high-level international talents hasn't been taken as a separate research topic, and the features of these talents haven't been fully analyzed. Thus, to fill in this research gap, this paper aims to study the evaluation of the cultivation quality of high-level international talents. In the second chapter, this paper proposed a framework for the ideas of international talent cultivation, established an EIS containing 4 basic elements of cultivation quality of knowledge ability, cultivation quality of application ability, cultivation quality of personal quality, and cultivation quality of creative ability for the said matter, and emphasized the importance of the training and testing of professional business English. In the third chapter, this paper gave the flow of the cultivation quality evaluation of high-level international talents, and adopted an EMD algorithm to the analysis of the quality change during the cultivation process; then, for the change trend of cultivation quality, at different time scales, a LSTM network was applied to training to get the predicted value of cultivation quality. At last, this paper employed experimental results to verify the effectiveness of the proposed model in predicting the cultivation quality evaluation of international talents.

2 Evaluation of the cultivation quality of international talents

Figure 1 shows the framework for ideas of international talent cultivation. After analyzing the features and elements of the cultivation quality of international talents, an EIS was established for the said matter, the EIS contains four basic elements of cultivation quality of knowledge ability, cultivation quality of application ability, cultivation quality of personal quality, and cultivation quality of creative ability. Figure 2 summarizes four main features of the quality of high-level international talents.

1st layer (first-level index):

ITT={ITT_1}={Evaluation of cultivation quality of international talents};

2nd layer (second-level index):

ITT_1={ITT_{11}, ITT_{12}, ITT_{13}, ITT_{14}}={Cultivation quality of knowledge ability, cultivation quality of application ability, cultivation quality of personal quality, cultivation quality of creative ability};

3rd layer (third-level index):

ITT_{11}={ITT_{111}, ITT_{112}, ITT_{113}, ITT_{114}}={Mastery of knowledge structure, foreign language ability, work experience, continual learning ability};

ITT_{12}={ITT_{121}, ITT_{122}, ITT_{123}, ITT_{124}, ITT_{125}, ITT_{126}}={risk prediction ability, overall planning ability, organization ability, coordination ability, negotiation ability, interpersonal ability};

ITT_{13}={ITT_{131}, ITT_{132}, ITT_{133}, ITT_{134}, ITT_{135}, ITT_{136}}={professionalism, honesty, keeping promises, decisiveness, rigor, resilience};

ITT_{14}={ITT_{141}, ITT_{142}, ITT_{143}, ITT_{144}, ITT_{145}}={Creative consciousness, knowledge transformation ability, practical ability, adaptability, willpower}.

The above-mentioned EIS could be regarded as an overall system V, the system contains four quality evaluation subsystems, namely the evaluation of the cultivation quality of knowledge ability, the evaluation of the cultivation quality of application ability, the evaluation of the cultivation quality of personal quality, and the evaluation of the cultivation quality of creative ability, which could be written as $V=\{v_1, v_2, v_3, v_4\}$, and each subsystem has several indexes. In the EIS, the evaluation of the quality of knowledge ability training is very important, especially the international talents' ability to use foreign languages in daily communication, and this ability can directly determine the completion and quality of foreign trade and other works they are engaged in. Generally, before actually taking the job positions, the talents need to participate in professional business English training and pass the international standard business English tests.

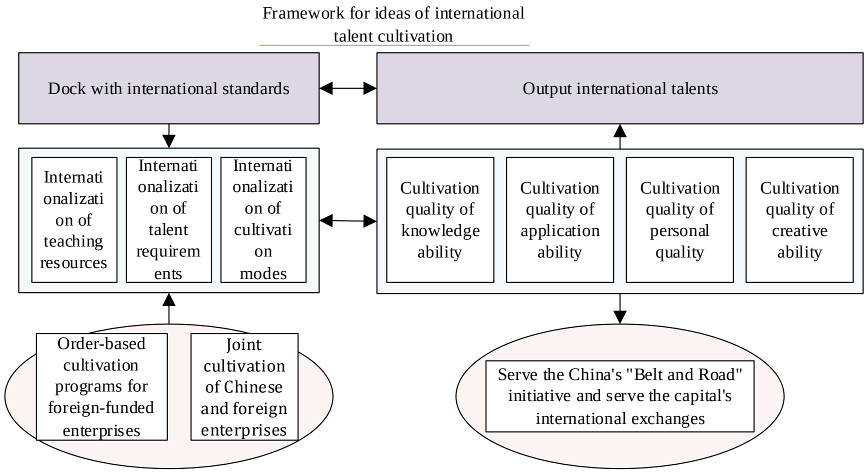

Fig. 1. Framework for ideas of international talent cultivation

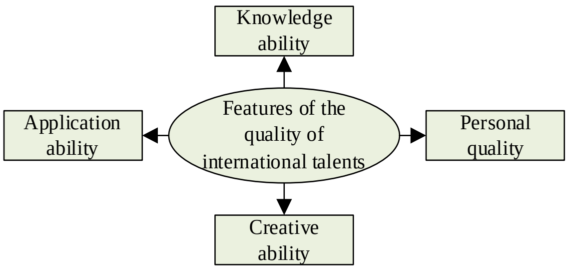

Fig. 2. Features of the quality of international talents

Assuming: n talents are going to participate in the evaluation of the cultivation quality of international talents, then the research of this paper could be regarded as a problem of using 21 evaluation indexes to give comprehensive evaluation to n samples. The performance of the evaluation objects was scored by experts, and every sample V_i was described by the values of these 21 indexes. Based on the scores of each evaluation object, an initial data matrix A of the cultivation quality of international talents could be constructed as:

$$A=\begin{bmatrix} a^1 \\ a^2 \\ \cdots \\ a^n \end{bmatrix}=\begin{bmatrix} a_{11}^1 & \cdots & a_{14}^1 & a_{21}^1 & \cdots & a_{26}^1 & \cdots & a_{41}^1 & \cdots & a_{46}^1 \\ a_{11}^2 & \cdots & a_{14}^2 & a_{21}^2 & \cdots & a_{26}^2 & \cdots & a_{41}^2 & \cdots & a_{46}^2 \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ a_{11}^n & \cdots & a_{14}^n & a_{21}^n & \cdots & a_{26}^n & \cdots & a_{41}^n & \cdots & a_{46}^n \end{bmatrix} \tag{1}$$

For evaluation indexes of different properties, the sizes of their ideal values are different as well. Assuming: the ideal value of the j-th evaluation index is a^*_j. For positive evaluation indexes, the greater the ideal value a^*_j, the better, and the maximum ideal value is $a^*_{j\text{-}max}$. For negative evaluation indexes, the smaller the ideal value a^*_j, the better, and the minimum ideal value is $a^*_{j\text{-}min}$. Therefore, according to the properties of evaluation indexes, the extreme values of the indexes can be found from the initial data matrix *A*, and ideal values of the indexes could be obtained from horizontal comparison. Assuming: a'_{ij} represents the degree of acceptance of a^*_j by a_{ij}, then for positive and negative indexes, there are: $a'_{ij}=a_{ij}/a^*_{j\text{-}max}$, $a'_{ij}=a^*_{jmax}/a_{ij}$. Formula 2 gives the definition of the standardized value:

$$o_{ij} = a'_{ij} / \sum_{i=1}^{n} a'_{ij}, \left(0 \le o_{ij} \le 1\right) \tag{2}$$

Further, the standardized data matrix $O=|o_{ij}|_{n\times m}$ of the evaluation indexes can be obtained.

Next, the index weights of the four quality evaluation subsystems were calculated. Taking the knowledge ability cultivation quality evaluation subsystem v_1 as an example, the number of indexes m_1 was 4. According to the standardized matrix o_1 of the evaluation index scores of each object to be evaluated in terms of subsystem v_1, the entropy value d_{1j} of the *j*-th index in v_1 can be further calculated based on Formula 3:

$$d_{1j} = -l\sum_{s=1}^{n} o_{1j}^{(r)} \ln o_{1j}^{(r)} \tag{3}$$

Assuming: $o^{(r)}_{1j}$ represents the standardized value of the *j*-th index in v_1 of the *r*-th sample. When $l>0$, l is equal to $1/\ln n$ and d_{1j} is greater than 0. Therefore, the difference coefficient of the *j*-th index in v_1 can be calculated by Formula 4:

$$h_{1j} = 1 - d_{1j} \tag{4}$$

Formula 5 gives the weight calculation formula of each evaluation index:

$$x_{1j} = h_{1j} / \sum_{j=1}^{m_1} h_{1j} \tag{5}$$

Assuming $X_1=[x_{11},x_{12},...,x_{1m1}]$ represents the weight vector of the entropy value of each evaluation index in the knowledge ability cultivation quality evaluation subsystem, based on above methods, for the other three subsystems, their difference coefficients and entropy weight vectors could be determined as well.

After that, index weight of the overall system of the evaluation of international talent cultivation quality was calculated. According to the steps of the entropy weight method given above, the difference coefficient h_{ij} of each second-level index was calculated, and then the difference coefficients of indexes in the lower layer were summed to get the utility value of each subsystem, which was denoted as $H_l(l=1,...,4)$. Formula 6 gives the formula for calculating the utility value of the overall system of the evaluation of international talent cultivation quality.

$$H = \sum_{l=1}^{4} H_l \tag{6}$$

The weight of indexes in category *L* can be written as $q_l=H_l/H(l=1,...,4)$. At last, for each evaluation object, the comprehensive evaluation value of international talent cultivation quality was calculated, and the calculation formula is:

$$g^{(r)} = \sum_{i=1}^{4}\sum_{j=1}^{m_i} q_j x_{ij} a_{ij}^{(r)}, i=1,...,4; r=1,...,n; j=1,...,m_i \tag{7}$$

3 Prediction of international talent cultivation quality based on deep learning

Figure 3 shows the evaluation flow of international talent cultivation quality. As can be seen in the figure, the cultivation of international talents is a continuous process. This paper adopted an EMD algorithm to analyze its change trend, the data sequence of international talent cultivation quality was stabilized to get the change trend under different time scales, which was then trained by the LSTM network to attain the corresponding predicted value of cultivation quality.

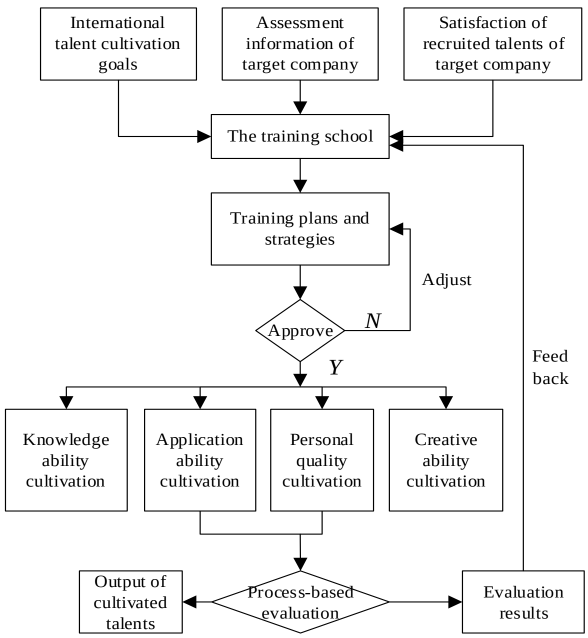

Fig. 3. The evaluation flow of international talent cultivation quality

The EMD algorithm had no basis function that was determined in advance, it can find all the extreme points of the upper and lower envelopes of the initial data sequence. The specific steps of the algorithm are as follows:

First, all maximum points of the initial data of international talent cultivation quality were determined and connected to form the upper envelope curve $a_{max}(u)$, and all minimum points were connected to form the lower envelope $a_{min}(u)$.

Based on $a_{max}(u)$ and $a_{min}(u)$, the mean value curve $EV_1(u)$ of $a_1(u)$ can be obtained:

$$EV_1\left(u\right)=\frac{a_{max}-a_{min}}{2} \tag{8}$$

Let $a_1(u)$ minus $EV_1(u)$ to get $f_1(u)$:

$$f_1\left(u\right)=a\left(u\right)-EV\left(u\right) \tag{9}$$

If $f_1(u)$ reaches the preset conditions, EMD terminates, and $f_1(u)$ is the residual component s_1. If $f_1(u)$ does not satisfy the termination conditions of EMD and satisfies the two conditions of the eigenmode function, then $f_1(u)$ is the first eigenmode function I_1 of $a_1(u)$, there is:

$$I_1\left(u\right)=f_1\left(u\right) \tag{10}$$

By finding the difference between $a_1(u)$ and $f_1(u)$, a new data sequence $a_2(u)$ with high frequency components removed could be obtained; then $a_2(u)$ was taken as a new data sequence to repeat the above steps until EMD terminates, then all m eigenmode functions and the residual component s_m were obtained. Formula 11 gives the expression of the initial data sequence of international talent cultivation quality:

$$a_1\left(u\right)=\sum\nolimits_{i=1}^{m}ing_i\left(u\right)+s_m \tag{11}$$

The EMD fuzzy prediction model was adopted to decompose the evaluation indexes of international talent cultivation quality to get the change trends of international talent cultivation quality at different time scales, namely the eigenmode function, which was then trained by the extreme learning machine, and the training results were fitted using the adaptive fuzzy reasoning algorithm to get the corresponding predicted value of cultivation quality. Figure 4 shows the prediction flow of the algorithm.

At first, the index data of the four quality evaluation subsystems were preprocessed to obtain the preprocessed data QU of international talent cultivation quality, the data was then normalized so that the value range of each index score was within [0,1], the normalized cultivation quality data QU' is:

$$QU'=\left[ITT_1\left(u\right),ITT_2\left(u\right),ITT_3\left(u\right),ITT_4\left(u\right)\right] \tag{12}$$

The normalized data of international talent cultivation quality within u days was sorted out into a piece of data, then, the international talent cultivation quality ME'

with m-u-z+1 pieces of data and 21×u features was obtained, $ME'=[q'_1, ...q'_v,...,q'_{m-u-z+1}]^T$.

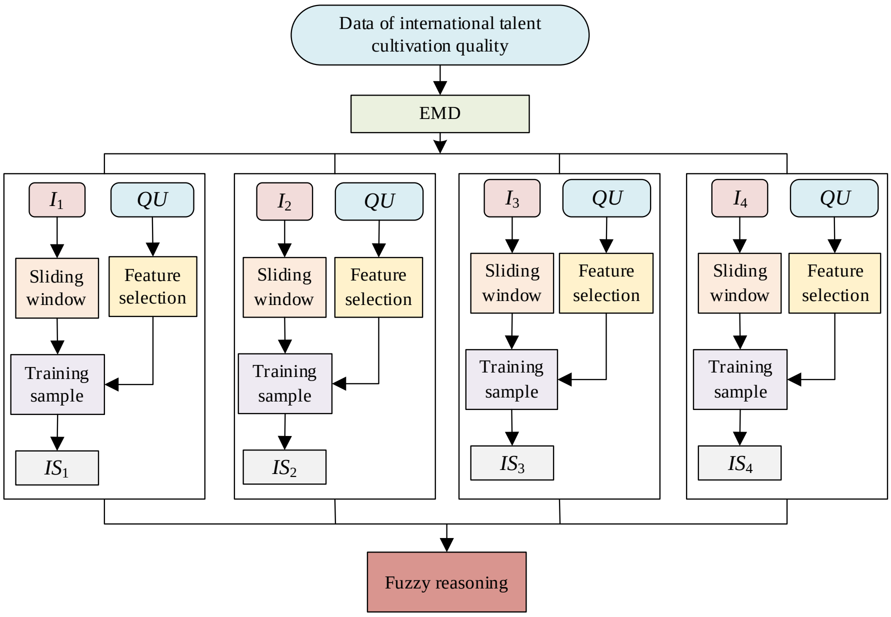

Fig. 4. Prediction flow of the algorithm

Then, QU was subject to EMD to get the change trend I_i of international talent cultivation quality of a certain evaluation object at different time scales.

Again, taking the knowledge ability cultivation quality evaluation subsystem v_1 as the example, at first, all extreme points in $ITT_1(u)$ were found; then, the curves of maximum and minimum values were fitted to get the upper and lower envelopes, which were denoted as $ITT_U(u)$ and $ITT_D(u)$; the envelope of mean value was denoted as $ITT_{AV\text{-}1}(u)$, namely the average value of $ITT_U(u)$ and $ITT_D(u)$:

$$ITT_{AV-1} = \frac{ITT_U(u) + ITT_D(u)}{2} \tag{13}$$

By finding the difference between the initial data sequence and $ITT_{AV\text{-}1}(u)$, a new data sequence $f^1_1(u)$ with low-frequency components removed can be obtained as follows:

$$f_1^1(u) = ITT(u) - ITT_{AV-1} \tag{14}$$

Because the change trend of $ITT(u)$ was complex and irregular, the calculated $f^1_1(u)$ did not satisfy the conditions of the eigenmode function. If $f^1_1(u)$ could meet the conditions of the eigenmode function by repeating above steps, then the first-order eigenmode function component of $ITT_1(u)$ can be expressed as:

$$I_1(u) = f_1^1(u) \quad (15)$$

By finding the difference between $ITT(u)$ and $I_1(u)$, a new data sequence $s_1(u)$ with high frequency components removed could be obtained as:

$$s_1(u) = ITT(u) - I_1(u) \quad (16)$$

For $s_1(u)$, above steps were repeated to get the second-order eigenmode function component $I_2(u)$. Similarly, the eigenmode function of *ITT* with *m* decompositions can be further obtained.

Then, *ME'* was processed based on the feature selection method *ReliefF*, combining with I_i, a sliding window with a size of $u+z$ was used to get the data of international talent cultivation quality of $u+z$ days, and two datasets *A* and B_i can be generated.

After subjected to EMD, although the data of international talent cultivation quality has different time scales, still it can correspond to *ME'* that had completed the feature selection, then $I_i(u)$ could be combined with *ME'* that had completed the feature selection. For $I_i(u)$, the first *u* values obtained by the sliding window could be combined with *ME'* to generate dataset A_i. Based on $I_i(u)$, the last *z* values obtained by the sliding window could generate dataset B_i.

The prediction result PV_i can be obtained by training datasets A_i and B_i using the LSTM network IS_i. The specific steps are as follows:

The first 75% and the last 25% of A_i were respectively taken as the input and output of the training set, and the first 75% and the last 25% of B_i were respectively taken as the input and output of the test set. The constructed single hidden layer LSTM network had *f* hidden neurons, the LSTM network training model IS_i and the predicted quality value PV_i corresponding a certain quality evaluation subsystem $I_i(u)$ could be obtained.

For the obtained predicted results PV_i of different quality evaluation subsystems, the fuzzy reasoning algorithm was adopted for fitting, and finally the final predicted result of cultivation quality was obtained, the specific steps are:

Assuming that the prediction result output by the LSTM network IS_i is $PV=\{PV_1, PV_2,...,PV_i,...,PV_m\}$, λ_G represents the membership function, then the output of the first layer of the fuzzy reasoning algorithm is:

$$P_{ij}^1 = \lambda_{G_j^i}(PV_i) \quad (17)$$

The output of the second layer of the fuzzy reasoning algorithm is:

$$P_i^2 = \theta_j = \prod \lambda_{G_j^i}(PV_i) \quad (18)$$

The output of the third layer of the fuzzy reasoning algorithm is:

$$P_i^3 = \overline{\theta_j} = \frac{\theta_j}{\sum \theta_j} \quad (19)$$

The output of the fourth layer of the fuzzy reasoning algorithm is:

$$P_i^4 = \overline{\theta_j} g_j = \overline{\theta_j}\left(\sum o_j PV_j + w_j\right) \tag{20}$$

The output of the fifth layer of the fuzzy reasoning algorithm is:

$$P^5 = \sum \overline{\theta_j} g_j = \frac{\sum \theta_j g_j}{\sum \theta_j} \tag{21}$$

4 Analysis of experimental results

Figure 5 is a comparison between the features after removing the performance feature and all the features. It can be seen that the feature selection operation has a certain impact on the accuracy of the prediction results of international talent cultivation quality evaluation. To verify the effectiveness of the constructed prediction model, comparative experiments were performed to compare the constructed model with support vector machine (SVM), K-nearest neighbor (KNN), random forest, and naive Bayes, and the results are shown in Figure 6. As shown in the figure, the proposed model outperformed other methods by more than 10% in terms of accuracy; also, the proposed model can maintain a stable prediction effect when the training set is large, and the prediction accuracy could be remained around 80%.

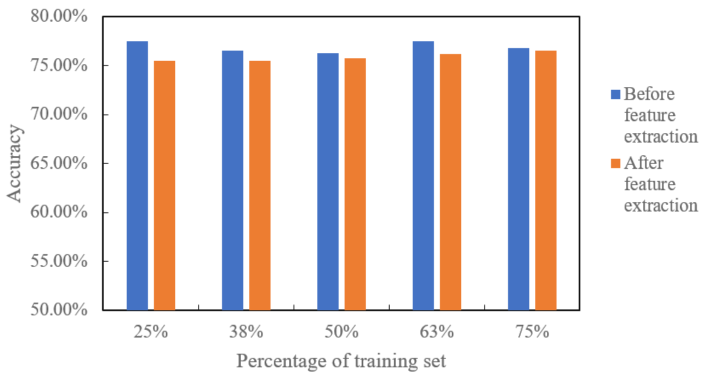

Fig. 5. Comparison of evaluation accuracy before and after feature extraction

Figure 7 gives the ROC curves of above mentioned models during the prediction process. According to the figure, the area under the ROC curve of the proposed model is the largest, so the proposed model is the best among these models.

Further, an accuracy evaluation model and a loss function were used to evaluate the effect of the proposed model in predicting the cultivation quality of international talents. Figure 8 and Figure 9 respectively give the model accuracy and the change of loss value. On the training set and test set, the prediction accuracy of the model was stable at around 0.821, and the loss value was stable at around 0.032, both of which were relatively ideal.

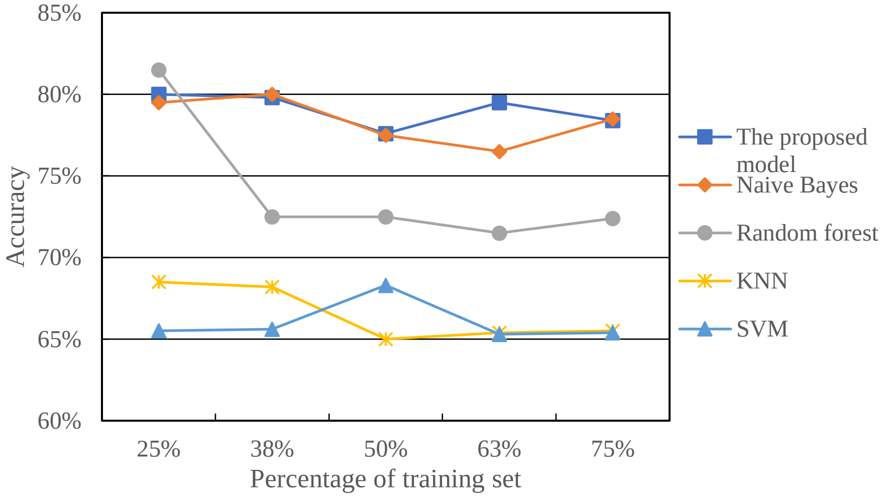

Fig. 6. Prediction results of different models

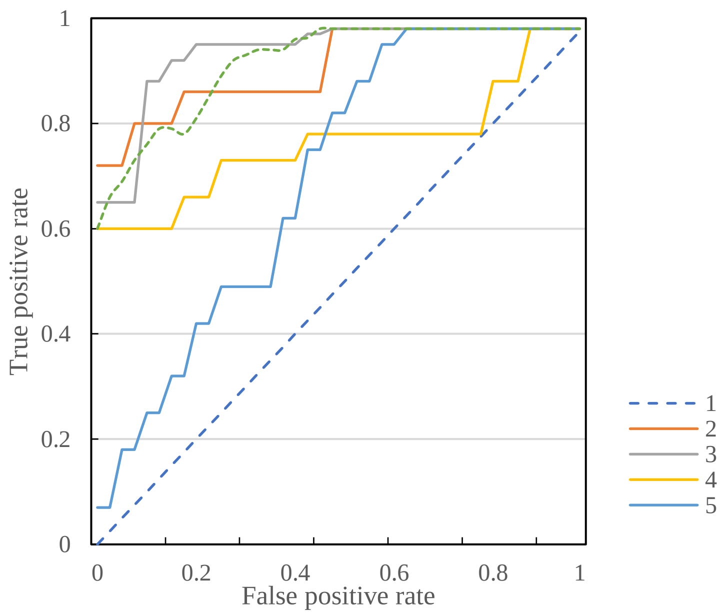

Fig. 7. ROC curves of models during prediction process

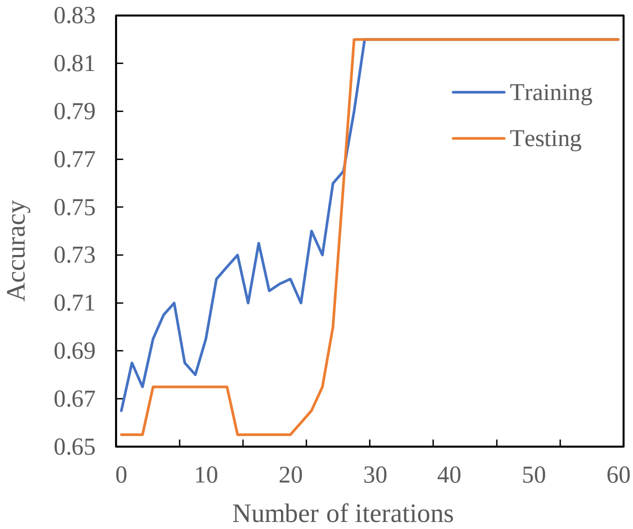

Fig. 8. Model accuracy curves

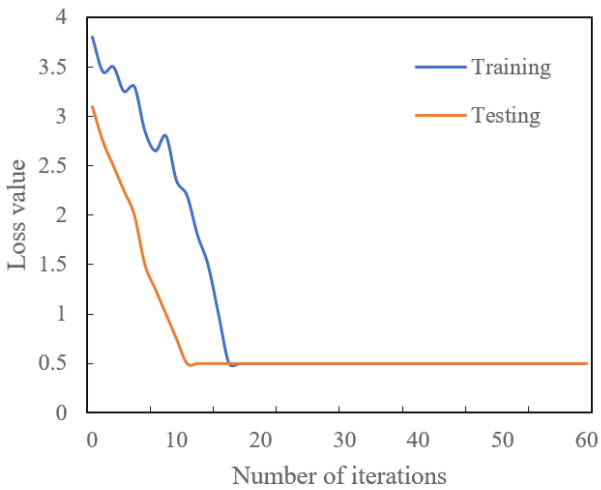

Fig. 9. Loss value of the model

5 Conclusion

This paper studied the evaluation of the cultivation quality of international talents based on deep learning. In the paper, at first, a framework of the ideas of international talent cultivation was given, an EIS containing 4 basic elements was proposed for the said matter, and the importance of the training and testing of professional business

English was emphasized. Then, this paper sorted out the evaluation flow, and adopted the EMD algorithm to analyze the change trend of cultivation quality. After that, the change trend under different time scales was trained by a LSTM network to get the predicted value of cultivation quality. In order to verify the effectiveness of the proposed model, this paper compared it with other 4 models of SVM, KNN, random forest, and naive Bayes in experiment, and the obtained results showed that the proposed model outperformed others by more than 10% in terms of accuracy. At last, this paper plotted the ROC curves, accuracy curves, and loss value change curves of the models during prediction process, the area under the ROC curve of the proposed model was the largest, indicating that it was the best among these models.

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