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Research on individual coordination scheme and countermeasure based on soft fuzzy rough set

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Abstract. In order to improve effectiveness of coordinated development strategy research of enterprise under concepts of social responsibility and ecological environment protection for enterprise, research strategy for coordinated development strategy of enterprise based on soft fuzzy rough set was proposed. Firstly, coordinated development strategy model for enterprise under concepts of social responsibility and ecological environment protection for enterprise was researched, and its prediction model for growth curve was constructed; at the same time, based on rough set theory, soft fuzzy rough set model was adopted. It was improved to make it have capacity to handle multi-strategy problems. This kind of model was utilized to predict effect of coordinated development strategy of enterprise and to get kind strategy prediction set for per coordinated development strategy. Finally, prediction result was assessed at the usage of special evaluation criterion of multi-strategy prediction.

Key words. Soft fuzzy, Rough set, Coordinated development, Prediction model.

1. Introduction

For coordinated development for enterprise and ecological environment, there is inseparable relation between them. That enterprise sets up excellent responsibility consciousness will be of great importance to positive development of ecological environment. Since the new century, global environment problems for global climate change, zone layer depletion and damaging and acid rain pollution etc. become increasingly severe.

Our country not only needs to deal with these common problems, but also shall face water environment pollution, rubbish treatment, water and soil loss etc. in our own national conditions. This has set up a severe test for China's enterprise in energy conservation and emission reduction. Seen from general enterprises, it is not

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that environment protection is not done, but we do not pay enough attentions to it. There are omissions in daily supervision. For example, there was an explosion in Double Benzene Plant for PetroChina Jilin Petrochemical Co., Ltd.. After explosion accident, it was found that benzene pollutants flew into Second Songhua River in monitoring, which caused water body pollution. It is surely because that personnel is not in place for explosion in Double Benzene Plant, which caused supervision loopholes and major pollution to water body of Songhua River. For example, Sanlu milk power incident in 2008, in order to reduce cost and make a large profit, personnel of the company added Melamine to its milk products. There are many such problems. In case enterprise directly related to those incidents can strengthen social responsibility and focus on hazard of its behavior to society just like focusing on economic profit. Vice versa, excellent ecological environment will also provide one big leaping environment again for enterprises, and it is believed that enterprise and ecological environment can jointly develop soundly. In new period, there are many discussion and researches that are devoted to strengthening social responsibility for enterprise to promote ecological environment and its coordinated development. For this problem, it is thought in the Thesis that social responsibility mechanism for enterprise shall be improved to realize coordinated development and ecological environment for enterprise, and conditions to guarantee this mechanism are support for service government and improved legal rules. Under the assistance of this level, energy efficiency and production technology can be improved for this internal reason of enterprise through external support to develop coordinately with ecological environment in high social responsibility attitude.

In order to improve effectiveness for coordinated development strategy research of enterprise under concepts of social responsibility and ecological environment protection for enterprise, one kind of research strategy for coordinated development strategy of enterprise based on soft fuzzy rough set was proposed in the Thesis. Growth curve prediction model for coordinated development strategy of enterprise under concepts of its social responsibility and ecological environment protection for enterprise was constructed, and effect for coordinated development strategy for enterprise was predicted by taking advantage of soft fuzzy rough set model to obtain kind strategy prediction set for per coordinated development strategy.

2. Mathematical model for economic analysis

2.1. Growth curve prediction model

For coordinated development strategy of enterprise under concepts of social responsibility and ecological environment protection for enterprise, growth curve model can be utilized for construction, and growth curve model is one kind of curve to describe growth process for creatures originally. For its shape is like S, it is also called S curve. It is found through observation that speeds for growth process of many things change slowly then gradually quickly. After it reach the quickest growth speed, it starts to slow down again. Finally, its growth speed is nearly approximate to dead state to reach some extreme. It is found through observation that its speed for growth process changes slowly then gradually quickly in coordinated development research for enterprise under concepts of social responsibility and ecological environment protection for enterprise. After it reaches some quickest growth speed, it starts to slow down again. Finally, its growth speed is nearly approximate to dead state to reach some extreme.

In case dy/dt presents growth speed for variable y, its growth curve can be described in the following differential equation:

$$dy/dt = (a - by)\, y\,. \tag{1}$$

This is one nonlinear ordinary differential equation. Supposing its initial value $y = y_0$ at the time of $t = 0$, appropriate parameter substitution can be conducted. Supposing $k = a/b$ and $m = (k - y_0)/y_0$, it can be obtained:

$$y = k/\left(1 + me^{-at}\right). \tag{2}$$

This equation is Logistic curve equation, and k, m and a are undetermined coefficients. They can be confirmed by taking advantage of curve fitting through historical data sequence of y, and y value in the future can be predicted through Equation (2).

2.2. GM (1, 1) model for grey prediction

Grey system refers to system with incomplete and inaccurate information to be as grey prediction, and GM (1,1) model is the mostly used one. It is model for first-order grey differential equation of 1 variable. Variable set $X^{(0)}$ shall be considered:

$$X^{(0)} = \left\{X^{(0)}\left(1\right), X^{(0)}\left(2\right), \cdots, X^{(0)}\left(n\right)\right\}. \tag{3}$$

Its corresponding differential model is:

$$\frac{dX^{(1)}}{dt} + aX^{(1)} = u\,. \tag{4}$$

Where, a is equation coefficient; u is endogenous variable, and they are both pending parameters. It is recorded as $\hat{a} = \{a, u\}^{\mathrm{T}}$; $X^{(1)}\left(i\right) = \sum\limits_{k=1}^{i} X^{(0)}\left(k\right)$ is 1 time growth sequence of original sequence $X^{(0)}$, and it is recorded as:

$$Z^{(1)}\left(k+1\right)^{(k=1)} = \left(X^{(1)}\left(k+1\right) + X^{(1)}\left(k\right)\right)\Big/2\,. \tag{5}$$

Through mathematical derivation, calculation equation for the following pending parameter that needs to be calculated can be obtained:

$$\hat{a} = \left(B^{\mathrm{T}}B\right)^{-1} B^{\mathrm{T}}Y_N \tag{6}$$

Where, expressions for B and Y_N are shown in Literature [3]. After calculation for

$\hat{a} = \{a, u\}^{\mathrm{T}}$ by taking advantage of Equation (5), there is one model:

$$\frac{dx^{(1)}}{dt} + ax^{(1)} = u\,. \tag{7}$$

And sequence for generating model:

$$\hat{x}^{(1)}\left(k+1\right) = \left(X^{(0)}\left(1\right) - \frac{u}{a}\right)e^{(-ak)} + \frac{u}{a}\,. \tag{8}$$

Through sequence of Equation (7), reduction sequence $\hat{x}^{(0)}\left(k\right), k = 2, 3, \cdots, n, \cdots$ taken as prediction result can be obtained. Thus, purpose of conducting variable value in follow-up time by taking advantage of GM (1, 1) prediction model through sequence $\hat{x}^{(0)}\left(m\right), m = 1, 2, \cdots, n$ can be reached. It can be known from Equation (7) that e-ak item for time k. When sequence needs to be predicted changes according to index law, GM (1, 1) model has relatively high prediction accuracy.

3. Soft fuzzy rough set model

3.1. Soft fuzzy rough set

Thinking of selecting soft threshold in soft margin SVM is introduced into fuzzy rough set theory in soft fuzzy rough set theory, and one kind of concept different from soft distance for recent distance method of original calculation sample was proposed.

Definition 1 Given one sample practice x and one sample entity set $Y = \{y_1, y_2, \ldots, y_n\}$, soft distance between x and Y is defined as

$$SD(x, Y) = \arg\max_i\{d(x, y_i) - C \times m_i\}, y_i \in Y, i = 1, 2, \ldots, n, \tag{9}$$

Where $d(x, y_j)$ is distance function between x and y_j, C is penalty factor, and m_i is sample quantity meeting condition of $d(x, y_j) < d(x, y_i), j = 1, 2, ..., n$.

One example of confirming soft distance is given in Fig.1. Supposing sample x belongs to Kind 1and other samples belong to Kind 2, Y shall be used to express this sample set. In case $y1$ is taken as one noise sample and is ignored, *SD(x, Y)* shall be $d2$. Therefore, one penalty item is needed to judge whether how many samples shall be ignored. In case one sample is ignored, C will be deducted for $d(x, y_j)$. For all candidate distances $d(x, y_j)$, $d(x, y_k) = \arg\max_i\{d(x, y_i) - C \times m_i\}$ shall be taken as soft distance between x and Y. That is to say distance $d'(x, y_j)$ is the maximum after punishing all ignored samples. About selection for parameter C.

On the basis of soft distances shown in Fig.1, soft fuzzy rough set can be defined as follows:

Definition 2 Taking U as one non theoretical domain, R is one fuzzy equivalence relation on U. F(U) is fuzzy power set of U. Soft fuzzy upper and lower

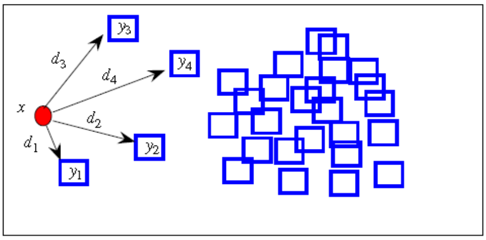

Fig. 1. Schematic diagram for soft distance

approximation for of F∈F(U)can be defined as

$$\begin{cases} \underline{R}^S F(x) = 1 - R\left(x, \arg_y \sup_{F(y)\leq F(y_L)} \{1 - R(x,y) - C \times m\}\right) \\ \overline{R}^S F(x) = R\left(x, \arg_y \sup_{F(y)\geq F(y_U)} \{1 - R(x,y) + C \times n\}\right) \end{cases} \tag{10}$$

Where,

$$\begin{cases} y_L = \arg_y \inf_{y\in U} \max\{1 - R(x,y), F(y)\} \\ y_U = \arg_y \sup_{y\in U} \min\{R(x,y), F(y)\} \end{cases} \tag{11}$$

C is one penalty factor, and m is quantity for ignored sample at the time of calculating $\underline{R}^S F(x)$. N is quantity for ignored sample at the time of calculating $\overline{R}^S F(x)$. In case set A is one clear set, membership degree of sample x to the soft fuzzy lower approximation can be expressed as

$$\underline{R}^S A(x) = 1 - R(x, y_{AL})\,. \tag{12}$$

Where

$$\begin{aligned} y_{AL} &= \arg_y \sup_{A(y)=0} \{1 - R(x,y) - C \times m\} = \arg_y \sup_{A(y)=0} \{d(x,y) - C \times m\} \\ &= \arg_y SD(x, U - A)\,. \end{aligned} \tag{13}$$

Obviously, $\underline{R}^S A(x)$ is equal to soft distance between sample x and $U - A$.

3.2. Soft fuzzy rough predictor

Hu Qinghua et al. designed one robust predictor [8] on the basis of the lower approximation definition for the above soft fuzzy which can be used to solve single strategy prediction. Its principle can be summarized as: value of one sample needs to be predicted to membership degree of the soft fuzzy lower approximation in every kind shall be calculated. Training sample set with k kinds and one sample c that needs to be predicted shall be given. Firstly, supposing x belongs to every kind, value of sample x to membership value for the soft fuzzy lower approximation of k kind shall be calculated, and x shall be predicted to the effect of the maximum membership degree. It can be expressed in equation

$$class_i(x) = \arg\max_{1\leq j\leq k}\{\underline{R}^S class_j(x)\} \tag{14}$$

Where, $\underline{R}^S class_i(x)$ is membership degree of x to the soft fuzzy lower approximation of kind $class_i$.

Algorithm is described as follows:

Input: training sample set $X = \{(x_1, y_1), (x_2, y_2), ..., (x_n, y_n)\}$, and test sample set $X' = \{x'_1, x'_2, ..., x'_m\}$;

Output: effect *classi* for per test sample x'_i.

Step1: calculate effect number;

Step2: for per test sample $x'_i \in X'$, the following treatment shall be conducted:

(1) For per kind *classj*$\in Y(Y = \{y_1, y_2, ..., y_k\})$, calculate distance between x'_i and per sample in different kind, and obtain candidate distance.

(2) For obtained candidate distance sequence, calculate corresponding soft distance for Kind *classj* according to Equation (3).

(3) It can be known from Equation (6) – (7), value of x'_i obtained in Equation (1) to soft distance for sample in different kind is equal to that for its corresponding lower approximation membership degree. Thus the lower approximation membership degree of sample x'_i to per kind was obtained.

(4) Corresponding kind strategy *classt* at the time of the maximum of membership degree shall be selected and returned, and effect for sample x'_i can be obtained.

Step3: repeat step2 until obtain kind strategy for per test sample.

3.3. Parameter setting

It can be seen from Fig.2 in 4.1 Section that value for penalty factor C in soft fuzzy rough set has important significance on its robustness. One method for parameter setting is shown in Literature [8].

Taking one sample x for example, credibility f for soft super ball that is subject to the sample as ball center shall be given. At the time of calculating credibility for soft super ball that is subject to x as ball center, in case its value is more than or equal to f, the difference between the radius of the soft super ball and the hard super ball is greater than that of the few different samples in the soft super ball, and specific value is obtained C value taking sample x as ball center. At the same time, credibility for the soft fuzzy lower approximation is guaranteed. For one data set containing n samples, calculated C average value that is subject to per sample as ball center shall be taken, and value for parameter C in this data set can be obtained.

For multi-strategy data set in the Thesis, parameter for per kind shall be selected through conversing multi-strategy data into several two prediction data set. BR method has different parameter value for different kind, which can be seen from Equation (9). Algorithm transformed by SFRC shall be subject to weighted average for per parameter as value for its penalty factor C, and weight is value for proportion of strategy quantity to all strategies in per kind, which can be obtained from Equation (10).

Equation to calculate parameter C is shown as follows:

$$C_i = \frac{SD(x, Y) - HD(x, Y)}{m}\,. \tag{15}$$

$$C = \sum_{i=1}^{L} w_i \times C_i\,. \tag{16}$$

Where, L is the total amount of strategy, and w_i is the weight of kind i. Credibility for the soft fuzzy lower approximation selected in the experiment of the Thesis is more than or equal to 95%, that is sample error rate in soft super ball is less than 5%.

4. Experimental analysis

4.1. Convergence experiment

Since the number of rough set input dimension increases exponentially when the input level is inevitably increase in the number of large structural complexity of the model and the training and learning time, in order to solve this problem , minimize the influence of subjective factors on the evaluation results, and in turn this evaluation method based on the use of hierarchical rough set, firstly use rough set training simulation in evaluating indicator, and use rough set training simulation in non-evaluating indicator. And, then use rough set training on their results again, and come up with a final evaluation of the results of the enterprise. Set for final evaluation result as $Y \to Z = \{$excellent, good, fair, poor$\}$. Among them, Y is the final output of the rough set, while Z corresponds performance evaluation for enterprise grade.

This paper uses training methods and soft fuzzy rough sets learning algorithm to calculate, and evaluating indicator rough set is constructed with three-tier model structure, in which the input layer node number is 15, the output layer node number number is 1 (the output is of the level of the evaluating position of the enterprise), number of hidden layer node number is 10 (determined according to Kolmogorov theorem), Rough set training error at this time of the smallest and shortest training time (its training error curve shown in Figure 2, where Performance is 0.000895863, Goal is 0.001); and non-evaluating indicator of rough set model structure is a made by four non-evaluating indicator as input, an output, and fuzzy layer has 16 node number, the number of fuzzy rules for the 256; the final rough set model structure includes two inputs (Level results and evaluating position of non-evaluating rating results), an output (enterprise performance evaluation results), fuzzy layer contains eight node number, and the number of fuzzy rules is 16. (its training data mean square error curve shown in Figure 3). From Figure 3, the mean square error is relatively smooth curve of the training data, model training is better.

After the final rough set training is completed,put the test sample in the well-trained rough set to carry out performance evaluation. Test results expected output in Figure 4 shows the actual output of the model. From Figure 4 , rough set model can be found in this article,which can build a completed better business performance evaluation. The error of its model between the predicted output and the expected output is tiny, and the degree of match is up to 90%. So it has a higher rating accuracy.

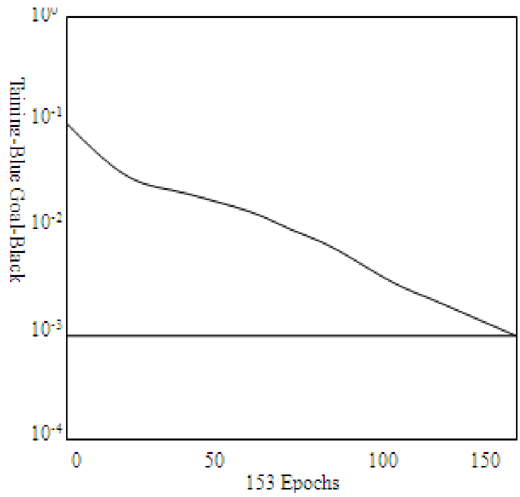

Fig. 2. RMSE change curve in training process

4.2. Comparison for prediction effect

Coordinated development research object adopted in Literature [5] shall be selected to analyze experiment, and contrast algorithm shall be subject to SVM algorithm. SVM is one kind of commonly used prediction model. Coordinated development strategy for multi-strategy enterprise were predicted by adopting SVM and multi-strategy prediction model for soft fuzzy rough set proposed in the Thesis. Prediction result for multi-strategy predictors is shown in Table 1.

Table 1. Prediction result for multi-strategy predictor

Index \ Algorithm	BR	
	Algorithm in the Thesis	SVM
ExactMatch	0.6280	0.6060
Hamming Loss	0.0537	0.1006
Accuracy	0.7957	0.7173
Precision	0.9229	0.7756
Recall	0.8154	0.7563
F-measure	0.8475	0.7605

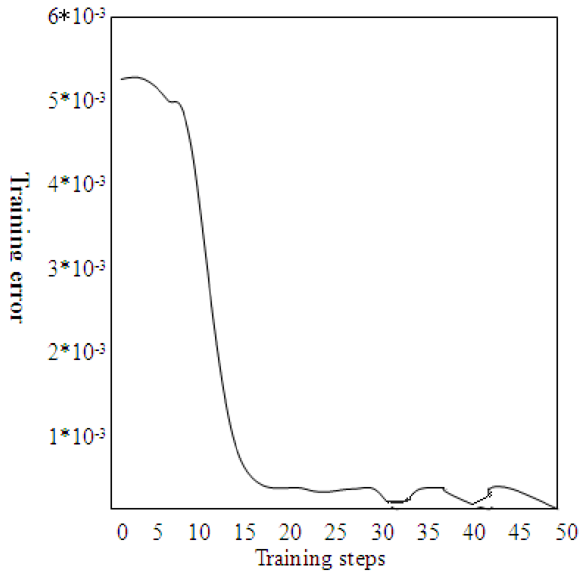

Fig. 3. Mean square error of the training data curve

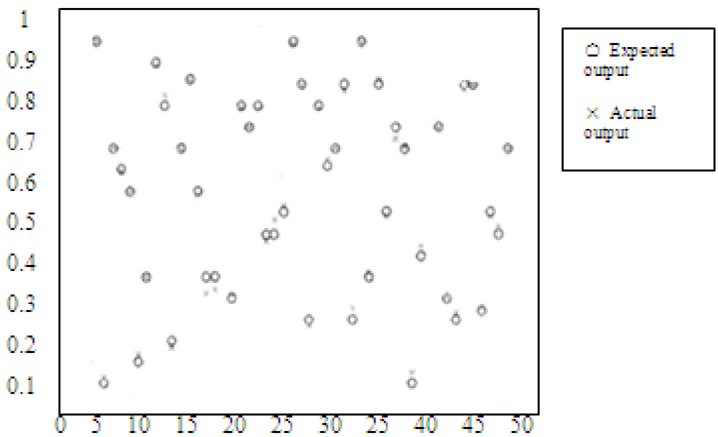

Fig. 4. Time output and expected output of models

It can be seen form Table 1 that under BR method, SVM algorithm and multi-strategy prediction model for soft fuzzy rough set in the Thesis can both realize effective prediction for coordinated development strategy of enterprise. But in can be seen from result that all indexes in obtained predicted results by utilizing SVM predictor are both worse than method proposed in the Thesis, which represents effectiveness of proposed algorithm.

Table 2. Influence result of threshold

Index \ Algorithm	Algorithm in the Thesis					
	90%	92%	94%	96%	98%	Mean
Exact Match	0.2990	0.3510	0.3870	0.3870	0.3090	0.6000
Hamming Loss	0.5128	0.4373	0.3588	0.2760	0.1988	0.1003
Accuracy	0.4630	0.5141	0.5577	0.5842	0.5606	0.7143
Precision	0.4811	0.5489	0.6234	0.7047	0.7702	0.7806
Recall	0.9694	0.9392	0.8924	0.8174	0.6827	0.7507
F-measure	0.5589	0.6033	0.6425	0.6704	0.6574	0.7583

It can be seen from Table 2 that prediction result obtained at the time of adopting boundary to get expected value is superior to that of giving one fixed threshold. Seen from effective prediction value for coordinated development strategy for enterprise, prediction result for non-fixed threshold is obviously lower than obtained prediction result at the time of adopting boundary to get expected value, which shows that prediction performance of algorithm in the Thesis is more excellent and represents advantage of algorithm prediction performance at the time of adopting boundary to get expected value.

5. Conclusion

One kind of research strategy for coordinated development strategy for enterprise based on soft fuzzy rough set was proposed in the Thesis. Coordinated development strategy model that is subject to soft fuzzy rough set for enterprise under concepts for social responsibility and ecological environment protection of enterprise was constructed. Effect for coordinated development strategy of enterprise was predicted to get kind strategy prediction set for per coordinated development strategy. Effectiveness for algorithm was verified in experimental result. The next step is mainly that enterprise development strategy of algorithm in real society shall be provided with example verification. Algorithm performance shall be analyzed further, and further optimization shall be considered.

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