

Applying PPE Model Based on RAGA in the Investment Decision-Making of Water Saving Irrigation Project

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Abstract: Through applying PPE model based on RAGA in the investment decision-making of water saving irrigation project, this study turns multi-dimension data into low dimension space. So the optimum projection direction can stand for the best influence to the collectivity. Thus, the value of projection function can evaluate each item good or not. The PPE model can avoid jamming of weight matrix in the method of fuzzy synthesise judgement, and obtain better result. The authors want to provide a new method and thought for readers who engaged in investment decision-making of water saving irrigation and other relative study. [Nature and Science 2003;1(1):57-61].

Key words: RAGA; PPE; water saving irrigation; investment; decision-making

1. Introduction

At present, more and more water-saving irrigation demonstration items have been developed broadly in many areas. Through carrying out these items, we can spread some water saving irrigation techniques according to local conditions, and use the water resource continually. In China, government has invested some items. So, many units compete to bid. Which unit should be chosen by decision-making to investing will be influenced by many factors. And that, many factors can't be quantitative change entirely. Thus, how to making a scientific decision is very important (Yan, 2000). At present, the method of fuzzy synthetic judgement has been applied broadly. But this method is short of the best criterion of system evaluation, and it will appear many errors or give us abnormal result. The method of giving weight subjectively and gray system evaluation has definite artificial factors. The evaluated method based on entropy calculates the weight of each index according to the mutation degree among indexes. This method can avoid the shortcoming of giving weight subjectively in a certain extent. But in fact, each weight will have the average value or the same value (Jin, 2000). The essential of synthetic evaluation is to handle with high dimension data. That is to reduce the dimension number. The weight matrix given by experts is corresponding to the projection value in low-dimension space of each index. The evaluation will be run in low-dimension space. But we can't ensure whether the weight matrix is the best projection in low-dimension space. Thereby, the author put forward a new technique named projection pursuit (PP) to reduce

the dimension number. Because it is very difficult to optimize many parameters at one time, the author applies genetic arithmetic (GA) that is fit for optimizing the multi-dimension and total scope to combine with PP model. Through optimizing the parameters at the same time with GA, the author can complete the decision process of water saving irrigation investment.

2. Projection Pursuit Evaluation (PPE) Model

2.1 Brief Introduction of PP Model

The main characteristics of PP model are as follows. Firstly, PP model can handle the difficulty named dimension disaster, which has been brought by high-dimension data. Secondly, PP model can eliminate the jamming, which are irrespective with data structure. Thirdly, PP model provides a new approach to handle high-dimension problem using one dimension statistics method. Fourthly, PP method can deal with non-linearity problem (Fu, 2003; Jin, 2000; Zhang, 2000).

2.2 Step of PPE Modeling

The step of building up PPE model includes 4 steps as follows (Fu, 2003; Jin, 2000; Zhang, 2000):

Step 1: Normalizing the evaluation indexes set of each sample. Now, we suppose the sample set is $\{x^*(i, j) | i=1 \sim n, j=1 \sim p\}$. $x^*(i, j)$ is the index value of j and sample of i . n —the number of sample. p —the number of index. In order to eliminate the dimension influence and unite the change scope of each index value, we can adopt the following formulas to

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normalize the data.

$$x(i, j) = \frac{x^*(i, j) - x_{min}(j)}{x_{max}(j) - x_{min}(j)} \quad (1-a) \text{ or:}$$

$$x(i, j) = \frac{x_{max}(j) - x^*(i, j)}{x_{max}(j) - x_{min}(j)} \quad (1-b)$$

In formula: $x_{max}(j)$ and $x_{min}(j)$ stand for the max and the min of j index value. $x(i, j)$ is the index list after moralization.

Step 2: Constructing the projection index function $Q(a)$. PP method is to turn p dimension data ($\{x^*(i, j) | j=1 \sim p\}$) into one dimension projection value $z(i)$ based on projection direction a .

$$a = \{a(1), a(2), a(3), \dots, a(p)\},$$

$$z(i) = \sum_{j=1}^p a(j)x(i, j) \quad (i=1 \sim n) \quad (2)$$

Then, we can classify the sample according to one-dimension scatter figure of $z(i)$. In formula (2), a stand for unit length vector.

Thus, the projection index function can be expressed as follows:

$$Q(a) = S_z \cdot D_z \quad (3)$$

In formula: S_z —the standard deviation of $z(i)$, D_z —the partial density of $z(i)$.

$$S_z = \sqrt{\frac{\sum_{i=1}^n (z(i) - E(z))^2}{n-1}} \quad (4)$$

$$D_z = \sum_{i=1}^n \sum_{j=1}^n (R - r(i, j)) \cdot u(R - r(i, j)) \quad (5)$$

In formula (4) and (5), $E(z)$ —the average value of series $\{z(i) | i=1 \sim n\}$; R —the window radius of partial density, commonly, $R = 0.1S_z$. $r(i, j)$ —the distance of sample, $r(i, j) = |z(i) - z(j)|$; $u(t)$ —a unit jump function, if $t \geq 0$, $u(t) = 1$, if $t < 0$, $u(t) = 0$.

Step 3: Optimizing the projection index function. When every indexes value of each sample have been fixed, the projection function $Q(a)$ change only according to projection direction a . Different projection direction reflects different data structure characteristic. The best projection direction is the most likely to discovery some characteristic structure of high-dimension data. So, we can calculate the max of $Q(a)$ to estimate the best project direction.

$$\text{Function: } \text{Max} : Q(a) = S_z \cdot D_z \quad (6)$$

$$\text{Restricted condition: } s.t. : \sum_{j=1}^p a^2(j) = 1 \quad (7)$$

Formula (6) and (7) are a complex non-linearity optimization, which take $\{a(j) | j=1 \sim p\}$ as optimized

variable. Traditional method is very difficult to calculate. Now, we adopt RAGA to handle the kind of problem.

Step 4: Classification. We can put the best projection direction a^* into formula (2), then we can obtain the projection value of each sample dot. Compare $z^*(i)$ with $z^*(j)$, if $z^*(i)$ is closer to $z^*(j)$, that means sample i and j are trend to the same species. If we dispose $z^*(i)$ from big to small, we can obtain the new sample list from good to bad.

3. Real Coding Based Accelerating Genetic Algorithm (RAGA)

3.1 Brief Introduction of GA

Genetic algorithm has been put forward by Professor Holland in USA. The main operation includes selection, crossover and mutation (Jin, 2000; Zhou, 2000).

3.2 Eight Steps of RAGA The coding mode of traditional GA adopted binary system. But binary system coding mode has many abuses. Through consulting the literature (Jin, 2000; Fu, 2003), the author put forward a new method named real coding based accelerating genetic algorithm (RAGA). RAGA includes 8 steps as follows. For example, we want to calculate the following best optimization problem.

$$\text{Max} : f(X)$$

$$s.t. : a_j \leq x_j \leq b_j$$

Step 1: In the scope of $[a_j, b_j]$, we can create N group uniformity distributing random variable $V_i^{(0)}(x_1, x_2, \dots, x_j, \dots, x_p)$. $i=1 \sim N$, $j=1 \sim p$. N —the group scale. p —the number of optimized parameter.

Step 2: Calculate the target function value. Putting the original chromosome $V_i^{(0)}$ into target function, we can calculate the corresponding function value $f^{(0)}(V_i^{(0)})$. According to the function value, we dispose the chromosome from big to small. Then, we obtain $V_i^{(1)}$.

Step 3: Calculate the evaluation function based on order expresses as $eval(V)$. The evaluation function gives a probability for each chromosome V . It makes the probability of the chromosome be selected to fit for the adaptability of other chromosomes. The better the adaptability of chromosome is, the much easier it will be selected. Now, if parameter $\alpha \in (0, 1)$, the evaluation function based order can be expresses as follows:

$$eval(V_i) = \alpha(1 - \alpha)^{i-1}, \quad i = 1, 2, \dots, N$$

Step 4: Selecting operation. The course of selecting is based on circumrotating the bet wheel N times. We can select a new chromosome from each rotation. The bet wheel selects the chromosome according to the adaptability. We obtain a new group $V_i^{(2)}$ after selecting.

Step 5: Crossover operation. Firstly, we define the parameter P_c as the crossover probability. In order to ensure the parent generation group to crossover, we can repeat the process from $i=1$ to N as follows. Create random number r from $[0, 1]$. If $r < P_c$, we take V_i as parent generation. We use V'_1, V'_2, \dots to stand for male parent that is selected. At the same time, we divide the chromosome into random pair based on arithmetic crossing method. That is as follows:

$$X = c \cdot V'_1 + (1-c) \cdot V'_2 \quad Y = (1-c) \cdot V'_1 + c \cdot V'_2$$

c —— a random number from (0,1).

We can obtain a new group $V_i^{(3)}$ after crossover.

Step 6: Mutation operation. Define the P_m as mutation probability. We select the mutation direction d randomly from R^n . If $V + Md$ isn't feasible, we can make M a random number from 0 to M until the value of $V + Md$ is feasible. M is an enough big number. Then, we can use $X = V + Md$ replace V . After mutation operation, we obtain a new group $V_i^{(4)}$.

Step 7: Evolution iteration. We can obtain the filial generation $V_i^{(4)}$ from step 4 to step 6, and dispose them according to adaptability function value from big to small. Then, the arithmetic comes into the next evolution process. Thus, the above steps have been operated repeatedly until the end.

Step 8: The above seven steps make up of standard genetic arithmetic (SGA). But SGA can't assure the whole astringency. The research indicates that the seeking optimization function of selecting and crossover has wear off along with the iteration times increasing. In practical application, SGA will stop to working when it is far away from the best value, and many individuals are conformed or repeated. Enlightening by the reference (Xiang, 2000), we can adopt the interval of excellence individual during the course of the first and the second iteration as the new interval. Then, the arithmetic comes into step 1, and runs SGA over again

to form accelerate running. Thus, the interval of excellence individual will gradually reduce, and the distance is closer to the best dot. The arithmetic will not stop until the function value of best individual is less than a certain value or exceed the destined accelerate times. At this time, the currently group will be destined for the result of RAGA.

The above 8 steps make up of RAGA.

3.3 PPE Model Based on RAGA

Take projection function $Q(a)$ as the most target function in the PPE model and the projection $a(j)$ of each index as optimized variable. Through running the 8 steps of RAGA, we can obtain the best projection direction $a^*(j)$ and projection value $z(i)$. To compare the $z(i)$ each other, we can obtain the evaluated result. At the same time, if we build PPE model about the soil grade evaluation standard according to the above steps, we will obtain the best projection value $Z(i)$. Then, through comparing the distance between $z(i)$ and $Z(i)$, the smallest distance between any two samples, then, the number i is the soil sample grade.

4. Application Example

Now, we use the data of Yan (2000) and Fu (2002) to give an example. The evaluated indexes about cost and benefit indexes are investment, self-investment, economy benefit, water saving rate, internal yield, benefit-cost ratio, years of investment and repayment, and so on. The factors that will influence the decision-making in the demonstration item of water saving irrigation are shown in the follows. These are degree of lacking water, measure of water saving, crop, society benefit, difficulty of construction, demonstrate function, construction enthusiasm and so on (Table 1, Table 2) (Yan, 2000; Fu, 2002).

Table 1. The Economy Evaluated Indexes in the Item of Water Saving Irrigation

County Name	1	2	3	4	5	6
investment per hectare (yuan/hm ²)	22800	11325	19200	6750	37950	3450
self-investment (yuan/hm ²)	5700	4650	7200	3450	9300	2700
economy benefit (yuan/hm ²)	5250	3450	4800	1800	6300	2250
water saving rate (%)	42	18	30	10	35	10
internal yield (%)	15	17	14	12	12.5	21
benefit-cost ratio	1.5	1.8	1.9	1.7	1.1	1.9
investment and repayment years (year)	8.6	6	7.8	5.5	8.8	4
project life (year)	20	10	15	8	16	5

Table 2. The Result After Handling the Evaluated Indexes in the Item of Water Saving Irrigation

County Name	1	2	3	4	5	6
1 investment per hectare	0.4391	0.7717	0.5435	0.9043	0	1.0
2 Self-investment	0.4545	0.2955	0.6818	0.1136	1.0	0
3 economy benefit	0.7667	0.3667	0.6667	0	1.0	0.1
4 water saving rate	1.0	0.25	0.6250	0	0.0556	1.0
5 internal yield	0.3333	0.5556	0.2222	0	0.0556	1.0
6 Benefit-cost ratio	0.5	0.875	1.0	0.75	0	1.0
7 investment and repayment years	0.0417	0.5833	0.2083	0.6875	0	1.0
8 project life	1.0	0.3333	0.6667	0.2	0.7333	0
9 degree of lacking water	0.9	0.8	0.6	0.8	0.4	0.5
10 measure of water saving	0.6	0.5	0.8	0.4	0.3	0.7
11 Crop	0.8	0.6	0.9	0.7	0.6	0.9
12 society benefit	0.8	0.6	0.7	0.8	0.8	0.7
13 difficulty of construction	0.8	0.6	0.8	0.5	0.6	0.9
14 demonstrate function	0.8	0.7	0.6	0.8	0.6	0.6
15 Construct enthusiasm	0.8	0.7	0.6	0.8	0.9	0.6

Now, we can build up PPE model based on the data in the Table 1 and Table 2. During the course of RAGA, the parent generation scale is 400 ($n=400$). The crossover probability is 0.80 ($p_c=0.80$). The mutation probability is 0.80 ($p_m=0.80$). The number of excellence individual is 20 ($\alpha=0.05$). Through accelerating 12 times, we can obtain the best projection value and it is 0.2618. The best projection direction: $a^*=(0.0558, 0.4213, 0.3816, 0.4150, 0.1199, 0.1080, 0.0459, 0.4881, 0.1117, 0.2700, 0.1677, 0.1803, 0.1715, 0.1535, 0.1903)$. Putting a^* into formula (2), we can obtain the projection value of each county. It is $z^*(j)=(2.4845, 1.5680, 2.2254, 1.1283, 2.0254, 1.2504)$. If we arrange $z^*(j)$ in big or small, we can know which county is the best. The result is $P1>P3>P5>P2>P6>P4$. Now, the synthetic benefit of P1 county is the best. P3 county and P5 county are the next. P2 county and P6 county are the following. P4 county is in the end. The PPE model has the same as literature (Jin, 2000), which applied fuzzy synthetic evaluation.

We can analyze the influence degree of each evaluated index according to the best projection direction. We arrange the a^* in big to small, then, the order numbers are 8, 2, 4, 3, 10, 15, 12, 13, 11, 14, 5, 9, 6, 1, 7. They are project life, self-investment, water saving rate, economy benefit, measure of water saving, construct enthusiasm, society benefit, difficulty of construction, crop, demonstrate function, internal yield, degree of lacking water, benefit-cost ratio, investment per hectare, investment and repayment years.

It is obvious that the PPE result can reflect the

practical condition basically. The contribution rate is consistent with the weight in fuzzy synthetic evaluation. The relation among the samples and the best projection direction see also to Figure 1 and Figure 2.

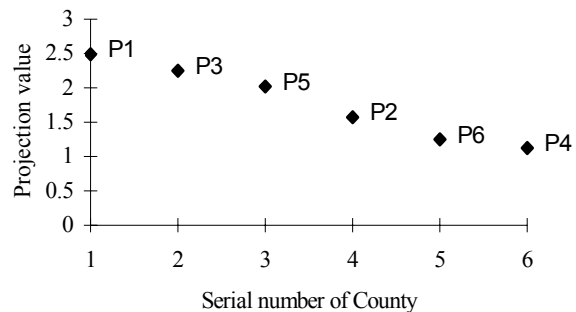


Figure 1. The Spread of Projection Value for Each County

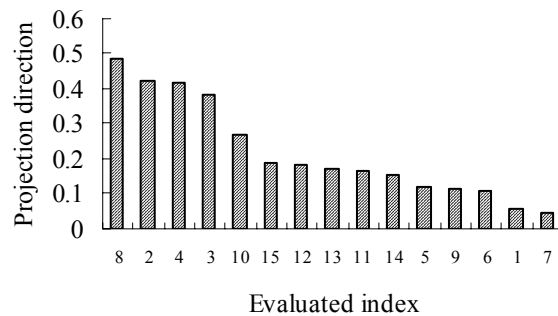


Figure 2. The Compositor of Projection Direction for Each Index

5. Conclusions

(1) The authors improved on SGA, and put forward a new method named RAGA. Through reducing the interval of excellence individual we accomplished the accelerate process. The method of RAGA can realize quick convergence and seek the best result in the whole

scope.

(2) Combing RAGA with PPE model, through using RAGA to optimize the many parameters in the PPE model, we can obtain the best projection direction of evaluation index of each county. The process of PPE modeling has been predigested. PPE model can be used in many other fields.

(3) Through applying the PPE model based on RAGA to the investment decision-making in the item of water saving irrigation, the authors do not only know which county is the best, but also obtain the important degree of each evaluated index. The result is good. Furthermore, the PPE model based on RAGA can be applied on some other research field about classification and evaluation.

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