OPTIMIZATION CONTROL OF E-BUSINESS INCOME BASING ON INTERVAL GENETIC ALGORITHM OF MULTI-OBJECTIVE

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Keywords: Interval Genetic Algorithm, Optimal Control, E-Business Income.

Abstract: In order to control the E-Business income, the relationship between 9 influencing factors and 3 controlling objectives is built by neural network. Then an interval genetic algorithm of multi-objective (IGAMO) is proposed to obtain the satisfactory interval solution instead of a single point solution provided by traditional algorithm. The IGAMO is constructed with 2-step genetic algorithm to find expending intervals satisfying the multiple income objectives, thus we gain the control conditions for influencing factors to make the income indexes fall in the anticipant intervals. The optimal control of E-Business income is proved to be feasible according to the analysis of the data collected from example e-Business enterprises of Guangzhou.

1 INTRODUCTION

E-Business control problem is a hot theme of researches in recent year (Pham, 2004; Lui et al., 2002). In our former work, an evaluation-factor system and an evaluation method are proposed according to the survey of the operation mode of E-Business of Guangzhou (Liu et al., 2005).The research outcome also bring out a valuable question: Can the relationship model between the influencing factors and income of E-Business be established, with which the E-Business income can be manipulated effectively by controlling the influencing factors? Many researches are focusing on predicting the income in future by the given values of influencing factors. However, works on setting the influencing factors at certain levels in order to control the E-Business income are rare.

Suppose there are t indexes reflecting the situation of E-Business income denoted as Y_i (i=1,2,…,t). For $Y_{i\text{-}min} \le Y_i \le Y_{i\text{-}max}$, how to determine the interval (c_j, d_j) of the influencing factor $\boldsymbol{x}_j$ (j=1,2,…,n)? That is to solve the optimal control problem of influencing factor $\boldsymbol{x}_j$ under the multiple conditions in (1).

$$Y_{i\text{-}min} \le Y_i \le Y_{i\text{-}max}, \quad Y=(Y_1, Y_2, \ldots, Y_t) \tag{1}$$

Since it is difficult to solve these global optimization problems with multiple objectives and variables by traditional methods, this paper takes advantage of interval genetic algorithm to solve them.

The rest of the paper is organized as follow: Section 2 presents the IGAMO; Section 3 apply the IGAMO to solve the optimal control of E-Business income basing on data of enterprises in Guangzhou. Section 4 concludes the paper.

2 INTERVAL GENETIC ALGORITHM OF MULTI-OBJECTIVE

Traditional genetic algorithm is to find the best individual $X^{(0)}=(X_1^{(0)}, X_2^{(0)} \cdots, X_n^{(0)})$ which is called the satisfactory solution. In fact, it is too demanding to fix factors at certain values in real control problem. Therefore, a more practical way is to search for a series of optimal intervals of influencing factors $\boldsymbol{x}_j$ to satisfy (1).

IGAMO is a two-step genetic algorithm aiming at figuring out the optimal intervals: the first step genetic algorithm is to find out the satisfactory

Liao Q. and Tang Z. (2007).
OPTIMIZATION CONTROL OF E-BUSINESS INCOME BASING ON INTERVAL GENETIC ALGORITHM OF MULTI-OBJECTIVE.
In *Proceedings of the Third International Conference on Web Information Systems and Technologies - Society, e-Business and e-Government / e-Learning*, pages 200-203
DOI: 10.5220/0001264502000203

solution while the second step is to determine the optimal control intervals basing on the satisfactory intervals expanded from the satisfactory solution. The relationship of dependent variables Y=(Y_1, Y_2 ,…, Y_t) and the influencing factors x_j, x_j,…,x_j is shown as follow:

$$Y_i = F_i(x_1, x_2, \cdots, x_n) = f(\sum_{q=1}^{M} V_{iq} f(\sum_{j=1}^{n} w_{qj} x_j - \theta_q) - r_i) \quad , \tag{2}$$

$$Y_{i-\min} \le Y_i \le Y_{i-\max}, a_j \le x_j \le b_j, i = 1, 2, \cdots, t, j = 1, 2, \cdots, n$$

where F_i is a BP Neural Network model, $V_{iq}$are the connection weight of output and hidden neurons while w_{qj} of hidden and input neurons, θ_q, r_i are thresholds and f is sigmoid function.

2.1 Obtaining the Optimal Solution

For every $j\,(j = 1,2,\cdots,n)$, randomly generate N genes $x_j^{(k)}$ $(k = 1,2,\cdots,N)$, respectively from $[a_j, b_j]$,thus the k^{th} individual is denoted as $X^{(k)} = \{x_1^{(k)}, x_2^{(k)}, \cdots, x_n^{(k)}\}$, then the population with N individuals is $S = \{X^{(1)}, X^{(2)}, \cdots, X^{(N)}\}$ and the dependent variables of $X^{(k)}$ in S is $(Y_1^{(k)}, Y_2^{(k)}, \cdots, Y_t^{(k)})$ .The midpoint is presented as $Y_{i-mid} = \frac{Y_{i-\min} + Y_{i-\max}}{2}$ and the fitness function is defined as:

$$F(X^{(k)}) = \frac{1}{\sum_{i=1}^{t} (Y_i^{(k)} - Y_{i-mid})^2 + \alpha} + \sum_{i=1}^{t} \beta_i \,\mathrm{sgn}(D_i) \tag{3}$$

where $\alpha, \beta_i > 0$ and

$$D_i = \frac{Y_{i-\max} - Y_{i-\min}}{2} - \left| Y_i^{(k)} - Y_{i-mid} \right| , \quad \mathrm{sgn}(D_i) = \begin{cases} D_i \,, D_i > 0 \\ 0 \ \ , D_i > 0 \end{cases} \tag{4}$$

Parameters α, β_i guarantee the existence of individuals that satisfy (1).

The first step of genetic algorithm is to search for and obtain the optimal individual $X_0 = (x_1^{(0)}, x_2^{(0)}, \cdots, x_n^{(0)})$ touching or closest to $(Y_{1-mid}, Y_{2-mid}, \cdots, Y_{t-mid})$.

2.2 Generating Optimal Intervals

Having found out the optimal individual $X_0 = (x_1^{(0)}, x_2^{(0)}, \cdots, x_n^{(0)})$, to determine the intervals for factors x_j, let $C_j = \max_{1\le k\le N}\{x_j^{(k)}\} - \min_{1\le k\le N}\{x_j^{(k)}\}$,where $x_j^{(k)}$ are genes from the individuals marked in the first step. Generate the positive real number ε_j

$$\varepsilon_j = \min\{b_j - x_j^{(0)}, x_j^{(0)} - a_j, C_j/2\} \ , \ j = 1, 2, \cdots, n \tag{5}$$

So the satisfactory solution is expanded from single points $\boldsymbol{x_j}$ to centre fixed intervals $(x_j^{(0)} - \varepsilon_j, x_j^{(0)} + \varepsilon_j)$, M new individuals $X^{(k)} = (x_1^{(k)}, x_2^{(k)}, \cdots, x_n^{(k)})$ are randomly generated from intervals $(x_j^{(0)} - \varepsilon_j, x_j^{(0)} + \varepsilon_j)$, $k = 1, 2, \cdots, M$.

Then S' is the new population possessing $M+1$ individuals $X^{(0)}, X^{(1)}, \cdots, X^{(M)}$. The fitness function is defined as (3).

The second step genetic algorithm is carried out with these $M+1$ individuals. After a certain times of evolutions through the defined crossover operator and mutation operator, we gain individuals whose fitness is no less than that of X_0.

All the individuals that satisfy all $\left| Y_i^{(k)} - Y_{i-mid} \right| < \frac{Y_{i-\max} - Y_{i-\min}}{2}$ $(i = 1,2,\cdots,t)$ are sorted by the fitness value in descending order and the top w individuals are chosen.

Suppose the j^{th} gene of the w individuals are ranked from small to big as $\tilde{x}_j^1, \tilde{x}_j^2, \cdots, \tilde{x}_j^w$, so the corresponding interval of the j^{th} gene is $[\tilde{x}_j^1, \tilde{x}_j^w]$, $j = 1, 2, \cdots, n$.

2.3 Statistical Test

To calculate the probability of the output Y=(Y_1, Y_2,…, Y_t) of the combination of values randomly selected from the n intervals $[\tilde{x}_j^1, \tilde{x}_j^w]$ obtained in the second step, which are supposed to satisfy that $Y_{i-min} \le Y_i \le Y_{i-max}$, this paper hold a random test with H test samples. Select $\boldsymbol{x_j}$ from intervals $[\tilde{x}_j^1, \tilde{x}_j^w]$ to form individuals $X^{(k)} = \{x_1^{(k)}, x_2^{(k)}, \cdots, x_n^{(k)}\}$ $(k = 1, 2, \cdots, H)$, calculate $\{Y^{(1)}, Y^{(2)}, \cdots, Y^{(H)}\}$ with $\{X^{(1)}, X^{(2)}, \cdots, X^{(H)}\}$, compared with the anticipant intervals of dependent variables and count the quantity of $Y^{(j)} = (Y_1^{(j)}, Y_2^{(j)}, \cdots, Y_t^{(j)})$ which satisfy $Y_{i-\min} \le Y_i^{(j)} \le Y_{i-\max}$, then the frequency of individuals' output bounded in the anticipant intervals is obtained to describe the probability that the outputs of the combination of $\boldsymbol{x}_j$ derived from $[\tilde{x}_j^1, \tilde{x}_j^w]$ are in the anticipant intervals.

By the process mentioned above, we have the optimal intervals for multiple variables $\boldsymbol{x}_j$ and the control probability with $Y_{i\text{-}min} \le Y_i \le Y_{i\text{-}max}$.

3 OPTIMIZATION CONTROL OF E-BUSINESS INCOME

3.1 e-Business Income and the Influencing Factors

Basing on the evaluation-factor system established in (Liu et al., 2005), the circumstance of E-Business income is evaluated by three indexes: Profit growth rate ($\boldsymbol{Y}_1$), Turnover rate ($\boldsymbol{Y}_2$), Sales profit rate ($\boldsymbol{Y}_3$) while the influencing factors are concluded as follow: Customer resources ($\boldsymbol{x}_1$), Customer service ($\boldsymbol{x}_2$), Delivery system ($\boldsymbol{x}_3$), Online transaction system ($\boldsymbol{x}_4$), Construction of software & hardware ($\boldsymbol{x}_5$), Combination of inner and outer information management ($\boldsymbol{x}_6$), Network technique & service ($\boldsymbol{x}_7$), Marketing for internet ($\boldsymbol{x}_8$), Training ($\boldsymbol{x}_9$). 20 groups of data collected from example E-Business enterprises of Guangzhou are showed in Table 1.

The values of these factors are scores in interval [0, 5] determined by E-Business experts. The three indexes of E-Business income are produced by the data collected during the investigations of a number of enterprises. The value of turnover rate should be real number in the interval [0, 1] while the other two in the interval [0, +∞].

3.2 Interval Optimization Control Model of e-Business Income

According to (1), let n=9, t=3, M=12. The BP neural network model of three income indexes and 9 influencing factors is built up by learning samples and tested by test samples. Table 2 shows the parameters.

Table 1: Income and influencing factors of e-Business.

x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	Y_1	Y_2	Y_3
4.5	5.0	3.8	4.9	4.7	4.1	4.9	4.5	3.2	11.90	40.47	13.46
2.6	4.6	4.1	3.6	4.7	4.6	4.7	4.9	2.4	10.56	68.23	14.04
3.7	2.6	3.2	4.0	4.5	4.9	1.9	3.8	1.8	6.61	35.39	8.208
4.4	4.6	3.2	3.9	4.5	4.7	1.7	2.8	1.4	9.44	28.84	9.204
4.9	4.8	2.9	3.8	4.5	4.9	1.6	4.0	4.2	4.26	38.59	8.052
4.6	3.0	2.9	2.6	5.0	1.2	1.7	2.6	3.7	9.42	24.91	7.135
4.6	2.5	2.3	3.7	4.8	4.7	2.2	3.4	4.4	8.66	24.17	9.028
4.6	2.8	2.7	3.7	4.9	4.0	1.9	1.6	3.6	4.36	35.91	7.266
4.5	4.7	1.6	4.2	4.7	4.8	2.4	3.5	3.9	5.27	42.97	7.549
4.5	4.7	3.2	3.9	4.6	5.0	1.1	1.6	4.2	8.81	16.77	9.141
4.5	2.1	2.9	3.6	5.0	4.9	2.3	2.9	2.0	7.65	37.34	8.509
4.4	3.8	2.7	3.4	5.0	2.6	3.7	3.9	2.7	5.04	39.54	8.280
4.4	3.2	1.8	3.7	4.5	0.8	4.6	4.7	4.8	8.86	38.64	9.462
3.5	3.9	3.6	4.0	4.5	1.9	4.3	4.0	4.0	9.37	24.36	6.565
0.6	4.8	3.4	4.3	4.5	1.1	4.1	4.7	4.7	7.02	18.65	7.809
2.8	3.6	3.8	4.3	4.8	2.8	3.6	4.5	2.5	9.80	20.31	7.882
3.8	2.2	3.6	3.2	4.3	3.6	2.9	2.0	3.5	1.81	13.31	6.939
3.1	4.9	2.9	3.8	2.7	3.8	0.8	2.1	2.8	1.99	23.86	5.810
4.6	1.7	2.0	3.8	3.5	4.8	1.8	2.0	1.4	4.18	8.26	6.119
1.8	3.0	1.7	3.1	4.9	3.4	3.8	4.3	2.4	4..51	17.27	6.521

Table 2: Parameters of BP NN evaluation model of income.

Input neurons	Hidden neurons	Output neurons	Training times	Total error	Total test error
9	12	3	20000	0.01	0.017

The anticipant range of these income indexes-Profit growth rate ($\boldsymbol{Y}_1$), Turnover rate ($\boldsymbol{Y}_2$) and Return on investment ($\boldsymbol{Y}_3$)) are shown in Table 3.

Table 3: Anticipant range of indexes of E-Business income.

Indexes	Y_1	Y_2	Y_3
Anticipant range	7%-9%	25%-35%	9%-11%

First, the midpoints of anticipant ranges are computed according to Table 3 shown below:

$$\boldsymbol{Y}_{1\text{-}mid}=0.08,\ \boldsymbol{Y}_{2\text{-}mid}=0.30,\ \boldsymbol{Y}_{3\text{-}mid}=0.10$$

With the definition of fitness function in (3), the first-step genetic algorithm is carried out and the optimal individual $X_0=(x_1^{(0)},x_2^{(0)},\cdots,x_9^{(0)})=(4.4382,4.8610,$ $3.5106,2.6649,4.5582,2.7313,3.2844,3.7715,2.2959)$, where the size of the population N=100; the selection rule is fitness-proportionate selection, the crossover rule is one-point crossover and the mutation rule is uniform mutation; the probability of crossover $\boldsymbol{P_c}$=0.5 while that of mutation $\boldsymbol{P_m}$=0.1, $\boldsymbol{\alpha}$=0.4,$\boldsymbol{\beta_1}$=0.45, $\boldsymbol{\beta_2}$=0.51, $\boldsymbol{\beta_3}$=0.38, times of evolution are 10000. Generate ε_j according to (4) to construct intervals $(x_j^{(0)} - \varepsilon_j, x_j^{(0)} + \varepsilon_j)$, which can be viewed in Table 4.

In order to find out the optimal intervals of $\boldsymbol{x_j}$, the second step is carried out: 500 individuals $\{X^{(1)}, X^{(2)}, \cdots, X^{(500)}\}$ are generated randomly with their gene $x_j^{(k)}$ selected from $(x_j^{(0)} - \varepsilon_j, x_j^{(0)} + \varepsilon_j)$. The fitness function is still defined by (3).When $\boldsymbol{P_c}$=0.5 ,$\boldsymbol{P_m}$=0.05, evolution times are 5000. It turned out that there are totally 491 individuals satisfying:

$$\left|Y_1^{(k)} - Y_{1-mid}\right| < 0.01, \left|Y_2^{(k)} - Y_{2-mid}\right| < 0.05, \left|Y_3^{(k)} - Y_{3-mid}\right| < 0.01$$

Let w=300, choose the top w individuals and the interval of the j^{th} gene, noted as $[\tilde{x}_j^1, \tilde{x}_j^{300}]$, generated from these individuals are shown in Table 5.

Table 4: Intervals of influencing factors in the first-step.

Factor	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9
$x_j^{(0)} - \varepsilon_j$	4.05	4.73	2.82	2.41	4.16	1.83	2.81	3.16	1.55
$x_j^{(0)} + \varepsilon_j$	4.82	4.99	4.19	2.91	4.95	3.63	3.75	4.37	3.03

Table 5: Final intervals of influencing factors.

Factor	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9
$\tilde{x}_j^1$	4.31	4.73	3.36	2.59	4.46	2.47	3.05	3.57	2.22
$\tilde{x}_j^{300}$	4.45	4.93	3.61	2.82	4.78	2.96	3.44	3.84	2.41

5000 test samples are generated in the corresponding intervals. Compare the outputs $\boldsymbol{Y_i}$ with the anticipant ranges. We conclude that the probability that the outputs fall in the anticipant ranges is about 99.5%, which means as long as the influencing factors are held at the levels between those shown in Table 5, the E-Business income could be controlled under the expectation shown in Table 3 effectively.

4 CONCLUSIONS

The interval genetic algorithm of multi-objective can effectively solve the optimization control problems with multiple objectives and variables, which can hardly be solved by traditional methods. Enterprises can control the E-Business income and profit effectively by taking the process control of the influencing factors. Not only does the result of this paper provide a feasible way to realize the anticipant income of E-Business but also can be promoted to the optimal control problems in other domains.

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