The AGA Evaluating Model of Customer Loyalty Based on E-commerce Environment

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Abstract—**With the development of e-commerce, the enterprises should build long-term and stable relationship with the customers, and then enhance customer loyalty continuously through the use of information technology and network technology, which based on the customer interest, meet the needs of clients and customers to create value for them as the goal. At the same time, for e-commerce beyond the limitations of time and space, so that the material, financial and information can high-speed flow, the sub-system, such as guide, ordering, payment, trade and security can be linked together organically , and then achieve the goods on-line trading. So face to the complex process and the huge information, how to obtain and retain more valuable customers and then establish and consolidate customer loyalty, which is the key for the enterprises strategy. Based on the analysis of the customer loyalty and problems which faced, this paper established an evaluation index system, including five aspects: customer expectations, customer trust, customer satisfaction, customer awareness value and transfer cost; this paper built customer loyalty model in e-commerce environment based on introducing the principles of GA method and improved program; the examples demonstrated that AGA method is scientific and operational on the issue of customer loyalty evaluation, and the AGA method can be applied to further areas; finally, this paper put forward the strategies of training and consolidating customer loyalty.**

Index Terms—**customer loyalty, e-commerce environment, GA, AGA, evaluation model**

I. INTRODUCTION

In the era of network rapid development, some companies have also entered the fanatical wave of building internet commerce; they have focused on how to attract customers and then ignored how to retain the loyal customers. In fact, in the network era, customer loyalty is especially important due to the uniqueness of e-commerce. Because loyal customer is a source of enterprises obtaining competitive advantage, who tend to purchase repeatedly products of this website and is not sensitive to price, but also pass a good reputation initiatively for Web site, recommend new customers, use this website products just as in the past and not change the trust of the site for the influence of the outside world. According to the findings of the United States agencies, customer loyalty increase 5%, corporate profits increase 25%-85%. Therefore, enterprises need a way to evaluate whether their customers loyal, segment customer and implement the different marketing strategies, so that is more conducive to the development of e-commerce sites.

A. Customer Loyalty

Customer loyalty is that the customers lock in your company and use your product ever since a long time ago, and will choose still your company while purchase a similar product the next time. We understand customer loyalty in two ways: ①Attitude and tropism: The attitude and tropism is on behalf of the customer-to-business products active-oriented degree, also reflects wishes for the customer recommending the products to other customers. Customer loyalty is that for the enterprises marketing or brand personality coincide with the consumer lifestyle or values, the consumers produce sentiment to the enterprises or the brand, even proud, and look it as themselves spiritual sustenance, and then show the desire of purchasing continuously. ②Conduct repeat: Conduct repeat is the possibility of the customers purchasing continuously the products in an enterprise, which can be measured by the indicators, such as ratio, order and possibility of the customers purchasing products etc. The continuous purchase behavior may come from the favorable impression to the enterprise products, may also come from the factors having nothing to do with feeling, such as the purchase impulse, the enterprise sales promotion activities, the customer purchase habits, the too high transfer cost, the customers can't purchase other products for the enterprise's market

dominance, or purchase other products inconveniently, and so on.

B. The Customer Loyalty Issues Under the Environment of E-commerce

The operation mode of e-commerce based on the information technology and network technology, which broken through the traditional corporate business model, and led to the important changes of the competition rules among the enterprises. Using the low-cost and the network rapid spread, we can acquire customers' requirement, strengthen ties with customers, excavate and manage effectively the customers' resources, attract and retain the customers, and then obtain the market competitive advantage, but having some issues of maintaining the relations with the customers in the virtual environment, as the following:

1) The lower information management level of business-to-customer

The businesses get the customer information through some ways, such as the membership registration, the questionnaire survey, etc; draw the useful customer behavior mode and a variety of potential information from large customer data information, treat differently the different customers, provide the favorable value services to the value customers, and then seize market opportunities, lay the foundation for the establishment of customer loyalty. While most enterprises have already established a background management system to safeguard customer basic data, but which is only as to retain customer information and failed to collect customer data for statistical analysis, can not get the evaluation and recommendations of customer-to-business-product, and even know noting about the customers acknowledge value. In addition, due to involving the customers' privacy in the personal data, the customers may provide false information; the enterprises lack the ability to identify, which resulting in a lack of authenticity of the customer data. As a result, enterprises can not identify and classify accurately based on the historical data and trading patterns of customers, and then lose the best communicating time with the valuable customers.

2) Customer-to-business lack of trust due to the imperfect mechanism

In the e-commerce market, because the economy and legal system can't catch up with the development pace of e-commerce far and away at present in China, the e-commerce transactions ways bring the separation of time and space between buyers and sellers, and then produce the trust and confidence difficulties. The reason is that the traditional reliance and confidence basis is weakened due to the virtual anonymity of e-commerce, a large-scale opening information infrastructure are very fragile facing to computer crime and network fraud, and e-commerce security can not obtain a good guarantee. As the difficult-easy degree of confidence-building between people has something to do with their trading methods, in e-commerce the customers often understand product only through the pictures or character description, the information asymmetry issue of product or service quality is more serious as a result of can not or difficulty to observe in the e-commerce market, so it is more difficult that a business wins the customers trust.

3) Enterprises lack the sense of establishing personalized service for the needs of different customers

In the e-commerce environment, customers will be able to skim over a large number of product information never leaving their home, which requires businesses Web sites to establish corresponding and effective communication mode and promotional content based on the consumers' different preferences, interests and demands, in order to complete one-on-one service in the low-cost, which requires companies to analyze the demands of the different customers. "Tailored" can meet the requirements, which can not only reduce the time of skimming over the product information based on the customers spend money, but also enhance the customers' satisfaction, and bring the loyal and stable customer base for businesses. However, the vast majority of enterprises mistake e-commerce for the networking of business activities makes the corporate Web site as the window of information dissemination; there is no use of the advantages of e-commerce to meet the customers' different demands, which can not maintain customer loyalty.

At present, there are gaps in training and consolidating customer loyalty methods for China enterprises in e-commerce environment. For a long time, China enterprises attach importance to qualitative analysis in customer loyalty evaluation; furthermore, these analysis methods are not comprehensive. It is indispensable to strengthening customer loyalty management, but with foreign customer loyalty management methods, which is lack of quantitative analysis and still imprecise in customer loyalty identification, measurement and other aspects. In addition, the biggest obstacle is customer loyalty information system construction seriously lagged behind in China enterprises improving customer loyalty management methods in e-commerce environment. For the large number of business and customers information deficiency, the enterprises unable to establish the corresponding management model and can't grasp accurately the customers exposure. Customer loyalty information is distortion, which impact directly the customer loyalty management decision-making scientificalness, and add more difficult to customer loyalty evaluation methods quantitative. In view of this, this paper constructs scientific evaluation index system, including five aspects: customer expectations, customer trust, customer satisfaction, customer awareness value and transfer cost, and solves lack of quantitative analysis problem through applying the Genetic Algorithm (GA), Adaptive Genetic Algorithm (AGA) and improved Genetic Algorithm.

II. THE CUSTOMER LOYALTY EVALUATION INDEX SYSTEM CONSTRUCTION IN THE E-COMMERCE ENVIRONMENT

A. The Characteristics of Customer Loyalty in E-commerce Environment

From the e-commerce characteristics, due to the use of the Internet, the establishing process of the customer loyalty is different from the traditional customer loyalty, the main characteristics show in the following areas:

1) Customers recommending is faster and broader

In the past customers recommending was through telephone or face-to-face manner, so it is slow and not wide range; in the age of e-commerce, the Internet as an ideal communication channel, which will enable the customers' happy consumer experience to be shared more quickly and widely due to the characteristic of the rapid spread, thereby culture and create greater opportunities to the customers loyalty.

2) Enterprises can provide greater value to customers

In the condition of Internet, the customers' demands can be better satisfied, such as the personalized demand, fast processing, etc, which is very difficult to achieve in the past.

3) Easier to build relationships of business-to-customer

The Internet is an interactive communication tool, which can not only facilitate the customers' feedback to the enterprise conduct, but also facilitate the enterprises to pay close attention to each customer, therefore, the excellent relations between the enterprise and customers is easier to establish. In contrast, the traditional communication channels, such the opinion letters, service phone, customers receive, etc, which are on pales beside.

4) The cost which enterprise acquire customers is greater, but the profit is higher

The virtual nature of the Internet led to uncertainty and risk of bargaining, so the enterprises must pay a much higher cost when build good relationship with the customers in early days. However, the enterprises use network tools to provide greater added value, so the customers have loyalty easily, along with the enterprises' profits will be greater.

B. The Customer Loyalty Evaluation Index System

1) Customer expectations (B_1)

In the e-commerce environment, customers can understand all business information in detail through network platform easily, and have an advance look forward to products or services of their interest; customers' demands further improve the specialization, personalization, convenience, quick response of product or service and so on, which are particular characteristics relative to the traditional business environment. Therefore, in the e-commerce environment should be an additional evaluation: the recommendation or word-of-mouth of the media and other customers (C_{11}); the related detailed product information quality and quantity of web site (C_{12}); Web site interactive (C_{13}) (time and convenience of searching for information); specialization of products or services (C_{14}); personalization of products or services (C_{15}); rapid response of products or services (C_{16}).

2) Customer trust (B_2)

In marketing trust theory, trust is the basis of loyalty directly, it is necessary to built customer trust in order to succeed in establishing a high level of long-term customer relationships, therefore trust is a decided factor of customer loyalty. Customer trust means dependent willingness customers to credible trading partners, including two dimensions, which are the credibility and goodwill: the strength of meeting the demand (C_{21}), honesty (C_{22}) and fairness (C_{23}) and so on. In the e-commerce environment should be an additional evaluation, which are safety (C_{24}) and reliability (C_{25}) of the site (payment security, privacy protection, security policies, credit system and legal environment, etc).

3) Customer satisfaction (B_3)

Satisfaction is a feeling state level, which comes from the comparison between perception performance or output for products or services and the expectations. Customer satisfaction is mainly the total of post-market evaluation supplier to existing customers: satisfaction to sales (C_{31}); satisfaction to the staff of after-sales, technical supporting and training (C_{32}); emotional factors (such as pleasure feelings) (C_{33}). In the e-commerce environment should be an additional evaluation, which is on-line services (C_{34}) (advice, help, application, registration, search and change, and so on).

4) Customer awareness value (B_4)

Customer awareness value is subjective evaluation of customers-to-supplier relative value, including: product features (C_{41}); product price(C_{42}); product quality(C_{43}); product branding(C_{44}); customer service(C_{45}) and other invisible costs(C_{46}) (conversion cost, use cost, time costs, spirit costs, physical strength costs, etc.). In the e-commerce environment, although the customers felt a large number of convenience due to the network, but also felt a lot of risk, therefore, should also be an additional evaluation of customer perception risk: products risk (C_{47}) (the customers can't experience and check personally product quality, and also can not distinguish the products types); security risk (C_{48}) (arising from the network trading, exchange data in an open networks, be likely to damage or leakage privacy).

5) Transfer cost (B_5)

Transfer cost refers to the related costs, involve which the customers and existing suppliers end the relationship, and establish a new replaced relationship, in the process of maintaining relations between the customers and former corporate, which is the results of time, energy, knowledge, feelings and the physical capital investing in products, services and relationship, including the relationship interests (C_{51}) (The special interests of customers due to relationships of business and customers, the competitors can not provide customers with the same interests in short order after customers conversion); the resource costs (C_{52}) (Including the cost of terminating service with existing provider and resources loss of transact with the new supplier, those, including money, time, energy and the property cost); the psychological costs (C_{53}) (Customer psychological pressure when convert product or service provider, including interpersonal conflicts and emotional risk-aware

conversion); alternative limit (C$_{54}$) (the number of product or service providers who customers can choose may also affect customer conversion behavior, which is objective obstacles while the customer conversion); additional services or service resumption (C$_{55}$) (including professional services for the customer personalized demand, all the actions and efforts of service organizations in order to make up for customer loss after the experience of services failure, the good service resumption can create value for customers and prevent effectively customers loss because of service failure). In the e-commerce environment, due to a sharp drop in corporate monopoly and the customer search costs, we should focus on evaluation of psychological costs and services costs in order to reduce the customer loss trends.

III. THE GA MODEL CONSTRUCTION

A. The Basic Principle of GA

Genetic Algorithm came of the computer simulation research to the biology systems. Professor Holland in Michigan University inspired by the biology simulation technology, created a self-adaptation probability optimization technology which fit for the complex system optimization based on the biology genetic and evolutionary mechanism, that is the genetic algorithm. Compared with the genetic algorithm, the most classical optimization algorithm is the gradient or higher time statistics based on a single measuring function (evaluating function) to produce a determinate experimentation solution sequence; Genetic algorithm is not dependent on gradient information, but search for the optimal solution through simulated natural evolutionary process. It uses the coding technology to act on the number bunch called chromosome, simulates the evolutionary process that composed of these number bunches. Genetic algorithm regroups the good adaptability bunches, and generates the new bunch groups through the organized and random information exchange.

B. The Model of GA

1) The indexes standardization

To the customer loyalty problems, we suppose the evaluating set A= {A$_1$, A$_2$, …,A$_n$}, the index set G= {G$_1$, G$_2$, …, G$_m$}, the index value of problem A$_i$ to index G$_j$ is x$_{ij}$ (i= 1, 2, … , n; j=1, 2, …, m). The comprehensive evaluating indexes of customer loyalty problems include customer expectations, customer trust, customer satisfaction, customer awareness value and transfer cost. Suppose the vector Q$_1$={G1, G2, …,G$_k$}denotes k customer expectations index, the vector Q$_2$={G$_{k+1}$, G$_{k+2}$, …,G$_p$}denotes p-k customer trust and satisfaction index, the vector Q$_3$={G$_{p+1}$, G$_{p+2}$, …,G$_q$}denotes q-p customer awareness value index, the vector Q$_4$={G$_{q+1}$, G$_{q+2}$, …,G$_m$}denotes m-q transfer cost index.

This paper carries through dimensionless disposal to the problems used fuzzy subjection function, the result is as follows:

X= {x$_{ij}$=|1,2,…,n; k=1,2,…,m}

For customer expectations index, its subjection function is:

$$y_{ij} = \begin{cases} 1 & x_{ij} \leq a \\ \dfrac{b - x_{ij}}{b - a} & a < x_{ij} < b \\ 0 & xi_j \geq b \end{cases} \quad (1)$$

(i=1, 2,…, n); j∈Q$_1$

x$_{ij}$ denotes the index value, y$_{ij}$ denotes the value after dimensionless disposal, a and b denote the maximum and the minimum of the indexes.

For customer trust and satisfaction index, its subjection function is:

$$y_{ij} = \begin{cases} 1 & x_{ij} \geq b \\ \dfrac{x_{ij} - a}{b - a} & a < x_{ij} < b \\ 0 & xi_j \leq a \end{cases} \quad (2)$$

(i=1,2,…,n); j∈Q$_2$

For customer awareness value index, its subjection function is:

$$y_{ij} = \begin{cases} 1 - \dfrac{q_1 - x_{ij}}{\max\{q_1, x_j^{min}, x_j^{max} - q_2\}} & x_{ij} < q_1 \\ 1 & q_1 \leq x_{ij} \leq q_2 \\ 1 - \dfrac{x_{ij} - q_2}{\max\{q_1, x_j^{min}, x_j^{max}(k) - q_2\}} & x_{ij} > q_2 \end{cases} \quad (3)$$

(i=1,2,…,n); j∈Q$_3$

For transfer cost index, its subjection function is:

$$y_{ij} = \begin{cases} 1 & x_{ij} = x_j^{m} \\ 1 - \dfrac{\left|x_{ij} - x_j^{m}\right|}{\max\limits_i \left|x_{ij} - x_j^{m}\right|} & x_{ij} \neq x_j^{m} \end{cases} \quad (4)$$

(i=1,2,…,n); j∈Q$_4$

In the formula, x$_j^{max}$ and x$_j^{min}$ denote the maximum and minimum value of transfer cost index respectively.

2) Determination of the objective function

Suppose the benchmark project Ao={x$_{0j}$| j=1, 2, ⋯ , m), the method to select the benchmark project is as follows:

To the customer expectations index, order:

$$x_{oj} = \min_{1 \leq i \leq n}\{x_{ij}\} \quad j \in Q_1 \quad (5)$$

To the customer trust and satisfaction index, order:

$$x_{oj} = \max_{1 \leq i \leq n}\{x_{ij}\} \quad j \in Q_2 \quad (6)$$

To the customer awareness value index, suppose the [q$_1$, q$_2$] is the optimal customer awareness value of the index value, order:

$$x_{oj} = x_j\left(x_j \in [q_1, q_2]\right) \quad j \in Q_3 \quad (7)$$

To the transfer cost index, suppose the x$_j^m$ is the optimal index fixed value, order:

$$x_{oj} = x_j^{m} \quad j \in Q_4 \quad (8)$$

Suppose the W= {w$_1$,w$_2$,...,w$_j$} is the index weight value, thereinto (j=1,2,...,m), and W meets the constraint condition:

$$\sum_{j=1}^{m} w_j^2 = 1 \quad (9)$$

The index value of the benchmark project A_0 After the standardization is $y_0 = \{y_{oj}|j = 1, 2, \cdots, m\}$, $w_j y_{0j}$ denotes the weighted comprehensive performance value of the benchmark project index, and the $w_j y_{ij}$ denotes the weighted comprehensive performance value of the project i. The change of the weighted comprehensive performance values between the project index and the benchmark project index should be stable relatively, namely, the smaller the deviation is, the better the project is. Suppose Z_i is the weighted comprehensive performance value deviation between project i and the benchmark project, the objective function can be given under the constraint condition (9):

$$\begin{cases} \min Z_i(W) = \sum_{j=1}^{m}(w_j y_{0j} - w_j y_{ij})^2 & (j=1,2,...n) \\ \sum_{j=1}^{m} w_j^2 = 1 \\ w_j \geq \varepsilon_j & (0 < \varepsilon_j < 1; j=1,2,...,m) \end{cases} \quad (10)$$

In the formula (10), ε_j is the stated minimum value of the index weighted vector, in order to solve the above problem, we can assembles the objective function as the objective function U(W) through the tantamount weight disposal:

$$U(W) = \sum_{i=1}^{n}\frac{1}{n}Z_i(W) = \sum_{i=1}^{n}\frac{1}{n}\sum_{j=1}^{m} w_j^2 (y_{0j} - y_{ij})^2 \quad (11)$$

The formula (11) divided by n on both sides of the equation, suppose F (W) = U(W)/n, we can gain:

$$F(W) = \sum_{j=1}^{m} w_j^2 \frac{1}{n^2}(y_{0j} - y_{ij})^2 = \sum_{j=1}^{m} w_j^2 (y_{0j} - \overline{y_j})^2$$

$$\overline{y_j} = \sum_{i=1}^{n}\frac{1}{n}y_{ij} \quad (12)$$

(j=1,2,…,m)

Then formula (10) can transfer into formula (13), namely, the objective function is:

$$\min F(W) = \sum_{j=1}^{m} w_j^2 (y_{0j} - \overline{y_j})^2$$

$$s.t.\begin{cases} \sum_{j=1}^{m} w_j^2 = 1 \\ w_j \geq \varepsilon_j \end{cases} \quad (13)$$

(0<ε_j<1; j=1,2,…,m)

IV. THE AGA AND IMPROVED GA MODEL

A. The AGA Basic Principle

The GA including proportion copy, adaptive exchange and mutation operation is known as the AGA. During the searching for the optimizing parameters, AGA can maintain the solution groups' diversity and convergence function through changing adaptively the exchange probability P_C and mutation probability P_m based on the solution groups' environment adaptive ability. AGA can control adaptively the search process and then get the global optimal solution through acquiring and accumulating automatically the knowledge about space

search in the search process. And prove that AGA has the global convergence by use of Markov chain, that is, AGA can converge to the optimal solution.

B. Adaptive Exchange Probability and Mutation Probability

Exchange operation and mutation operation play an important role in GA. Exchange operation plays a major role, which combines and exchanges the valuable information between the two individual, generates new future generations, and then accelerates the search speed greatly during the groups' evolution; Mutation operation plays an assistant role, which is accidental and secondary, can maintain the groups gene diversity. In the course of specific operations, the AGA can change exchange probability P_C and mutation probability P_m, maintain the diversity, prevent premature convergence, and then increase the calculation method speed and accuracy based on the individual specific circumstances. It is achieved that change adaptively P_C and P_m through inspecting the relationship between the groups' average fitness value f_{avg} and the largest fitness value f_{max}.

For simple genetic algorithm (SGA), under normal circumstances, when it reached a superior solution, the group move closer to the superior solution quickly, this can reduce the individual fitness differences, that is, f_{max}-f_{avg} lower. With the f_{max}-f_{avg} change, the formula of P_C and P_m are:

$$P_C = k_1 / (f_{max} - f_{avg}) \quad (14)$$

$$P_m = k_2 (f_{max} - f_{avg}) \quad (15)$$

P_C and P_m don't depend on any solution individual's fitness value, for all groups, P_C and P_m have the same value. High fitness degree solution individual and low fitness degree solution individual have the same exchange frequency and mutation frequency. When the groups converge to the optimal solution, P_C and P_m increase, and is likely to cause the high performance solution individual being destroyed in the vicinity of the optimal solution.

In order to overcome these problems, it is necessary to protect the good performance solution in the group. For the high fitness degree solution individual, we use the lower exchange probability P_C and mutation probability P_m to ensure the GA convergence; for the low fitness solution individual, we use the higher exchange probability P_C and mutation probability Pm to prevent SGA premature convergence. Therefore, P_C depends not only on f_{max}-f_{avg}, but also on the two series of fitness value used for exchange. Similarly, P_m depends not only on f_{max}-f_{avg}, but also on the fitness value of the pending mutation individual. The expressions of P_C and P_m are:

$$P_C = \begin{cases} k_1(f_{max} - f')(f_{max} - f_{avg}) & if \quad f' > f_{avg} \\ k_3 & if \quad f' < f_{avg} \end{cases} \quad (16)$$

$$P_m = \begin{cases} k_2(f_{max} - f)(f_{max} - f_{avg}) & if \quad f > f_{avg} \\ k_4 & if \quad f < f_{avg} \end{cases} \quad (17)$$

In the formula, f_{max} is the largest fitness degree of the group; f_{avg} is the average fitness degree of the group; f' is

the greater fitness degree of the two exchange series; f is the fitness degree value of the pending mutation individual.

General recommended value, $k_1=k_3=1$, $k_2=k_4=0.5$. The larger the P_C, the more new individual could be introduced in groups, but the too much exchange operation of P_C could lead to the groups non-evolutionary, because its speed may be faster in terms of undermining the high-performance character string structure than producing the new gifted individual. The smaller the P_C the lower speed of searching for new individual could lead to the stagnant. Exchange operation plays a major role in GA algorithm, which can increase greatly the search speed during the group evolution, so the value of P_C is often taken between 0.5 and 1.0. Mutation is a secondary operator, which is mainly used to increase the group changes. The low mutation rate can prevent the any one to remain the same forever during the search process, and guarantee the algorithm can search every point of the problem space; but the high mutation rate incline to search immediately. So the value of P_m is smaller, from 0.005 to 0.05. In the practical application process, we must adjust appropriately k_1 and k_2 to ensure the value of P_C and P_m in the certain reasonable limits.

C. Solving with the improved genetic algorithm

For the above non-linear programming problem, this paper solves with the improved genetic algorithm. The major steps are as follows:

1. Generate an initial solution group randomly. Suppose the initial solution group $U^l=\{x^l_j\}$, ($j=1,2,…,m$), t denotes the evolutionary generation.

2. Calculate the fitness function value of current solution. According to the fitness function definitions, calculate the chromosome (the candidate solutions) fitness function $eval(x^l_j)$, ($j=1,2,…,m$).

3. According to the proportion information of the chromosome, the bigger the fitness degree of the candidate solution is, the bigger the probability of participating to generate the next generation is.

4. Select two vectors of x_i^{11} and x_j^{11} with the probability P_c from the vector x_1^{11}, x_2^{11},…, x_i^{11},…, x_j^{11},…, x_m^{11}, carry through the intercrossing operations according to the new operator. Reserve a vector after the intercrossing operations randomly and discard another vector, gain the candidate solution $\{x_1^{11}, x_2^{11},…, x_i^{11},…, x_j^{11},…, x_m^{1+1}\}$.

5. Select a certain vector in determinate probability P_m among the vector set after the intercrossing operations, carry through the aberrance operations according to the new aberrance operator to the vector, and gain the candidate solution set of next generation $\{x_1^{1+1}, x_2^{1+1},…, x_j^{1+1},…, x_m^{1+1}\}$.

6. Suppose the Euclidean distance of the two vector solutions that the fitness degree is highest in the candidate solutions set is:

$$d = \left\| x_{max}{}^l - x_{max}{}^{l+1} \right\|$$

$$= \sqrt{(x^t_{max\,1} - x^{t+1}_{max\,1})^2 + … + (x^t_{max\,n} - x^{t+1}_{max})^2}$$

If $d \leq \varepsilon$, $x^* = x^{t+1}_{max}$ gains the overall smallest point, and the algorithm is convergent; Otherwise, transfers to

step 4, continues to solution's optimize convergence search.

V. APPLICATION EXAMPLES

Based on the former the index system, in this paper, we divide the customer loyalty degree into five grades, Ⅰ (Complete loyalty), Ⅱ (Severe loyalty), Ⅲ (Moderate loyalty), Ⅳ (Mild loyalty) and Ⅴ (No loyalty). According to the hidden layer nodes' empirical formula and combining training, we compare, adjust and then identify that five nodes is optimal in hidden layer, and the output layer has one node. Set the customer loyalty level Ⅰ - Ⅴ corresponding respectively the customer loyalty classification results of the network output: 0.1, 0.3, 0.5, 0.7, 0.9.

Beijing enterprises' data as a training sample, we carry out the network training of the entire customer loyalty evaluation. When the data learning removed from 0 regions, the learning convergence is very slow, and even arise paralysis phenomenon. To this end, we carry out standardization pretreatment of the training sample data, suppose X_{max} is the 2 times of No loyalty standard value, X_{min} is 0.1 times of Complete loyalty standard value, after the corresponding standardization, the variable is:

$$X = 0.1 + 0.8(X - X_{min})/(X_{max} - X_{min})$$

Then the data samples will be normalization in [0.1, 0.9], and the network learning speed accelerate. The unbiased variance of the learning output error reach 1E-5, the training end, and the evaluation results of the training samples as shown in table I.

TABLE I.
THE TRAINING RESULTS OF SAMPLE DATA

Customer loyalty	Complete loyalty	Severe loyalty	Moderate loyalty	Mild loyalty	No loyalty
Expected output	0.1	0.3	0.5	0.7	0.9
Network output	0.1006	0.3058	0.5074	0.6979	0.8942

Selecting and monitoring five enterprises' customer loyalty indicators in Shanghai, the processing data as shown in table II.

TABLE II.
THE CUSTOMER LOYALTY MONITORING DATA OF SHANGHAI ENTERPRISES

Monitoring point	Evaluation factor						
	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}	C_{21}
1	0.64	0.78	0.23	0.56	0.70	0.62	0.73
2	0.73	0.89	0.31	0.64	0.81	0.62	0.81
3	0.54	0.73	0.17	0.53	0.59	0.52	0.68
4	0.75	0.91	0.36	0.71	0.84	0.72	0.87
5	0.71	0.85	0.29	0.58	0.74	0.59	0.74

CONTINUE TABLE

Monitoring point	Evaluation factor						
	C_{22}	C_{23}	C_{24}	C_{25}	C_{31}	C_{32}	C_{33}
1	0.15	0.74	0.73	0.80	0.34	0.62	0.45

2	0.28	0.84	0.82	0.88	0.45	0.73	0.63
3	0.10	0.58	0.70	0.79	0.24	0.53	0.36
4	0.31	0.88	0.85	0.92	0.48	0.82	0.70
5	0.19	0.78	0.80	0.84	0.45	0.71	0.60

CONTINUE TABLE

Monitoring point	Evaluation factor						
	C_{34}	C_{41}	C_{42}	C_{43}	C_{44}	C_{45}	C_{46}
1	0.73	0.35	0.13	0.64	0.79	0.53	0.63
2	0.84	0.46	0.20	0.69	0.86	0.61	0.69
3	0.67	0.29	0.09	0.59	0.70	0.47	0.50
4	0.89	0.50	0.25	0.78	0.90	0.69	0.74
5	0.79	0.38	0.18	0.67	0.83	0.55	0.68

CONTINUE TABLE

Monitoring point	Evaluation factor						
	C_{47}	C_{48}	C_{51}	C_{52}	C_{53}	C_{54}	C_{55}
1	0.86	0.80	0.87	0.73	0.32	0.64	0.74
2	0.90	0.89	0.90	0.78	0.43	0.74	0.79
3	0.78	0.81	0.82	0.68	0.25	0.57	0.65
4	0.96	0.93	0.93	0.82	0.45	0.82	0.87
5	0.87	0.86	0.88	0.75	0.37	0.69	0.76

Compute the network output results' membership, according to customer loyalty and using principles of the membership biggest, judge customer loyalty rating of the different levels of membership, so we can see clearly the grade-level, and then through the analysis of the sample evaluation factor, we can understand clearly the worst loyalty rating factors, that is No loyalty factors. We infer according to the trained evaluation network, the evaluation results as shown in Table III.

TABLE III.
THE CUSTOMER LOYALTY LEVEL RESULTS BASED ON AGA EVALUATION

No	Network output	I(0.1)	II(0.3)	III(0.5)
1	0.416	0	0.19	0.81
2	0.257	0.21	0.79	0
3	0.781	0	0	0
4	0.126	0.73	0.27	0
5	0.348	0	0	0.77

CONTINUE TABLE

No	Network output	IV(0.7)	V(0.9)	Evaluation results
1	0.416	0	0	III
2	0.257	0	0	II
3	0.781	0.75	0.25	IV
4	0.126	0	0	I
5	0.348	0.23	0	II

For ease of comparison and analysis, we evaluate the monitoring data using the traditional BP algorithm and AGA, under the same conditions, which the learning error of the network training model is 1E-5, the convergence rate's comparison results between AGA network training model and traditional BP model as shown: the convergence time of AGA is 7.68 S, and the

convergence time of traditional BP model is 61.54 S. Clearly, AGA is not only faster than traditional BP algorithm, but also can overcome the problems of BP algorithm easily into the local minimum.

VI. CONCLUSIONS

A. The Summary of AGA

AGA is used in customer loyalty evaluation system in the e-commerce environment, integrate effectively the characteristics, that is, GA's global search ability is strong and gradient drop method's local search ability is strong, then GA's identification effect enhance. The network model doesn't have to re-determine the weight value of the evaluation factors, and can adjust automatically the ratio relationship of the various factors, so the evaluation results have strong objectivity. At the same time, Beijing enterprises' customer loyalty evaluation index data as the network operator samples, we evaluate the samples for evaluation using weight value and threshold value of computing end, the model's commonality is very good. The comparison of the traditional BP algorithm and AGA through the monitoring data showed that, customer loyalty evaluation method based on AGA is high speed and accuracy, which has highly robust, can reduce the network training number of times, shorten the network training time, simulate effectively the complex non-linear relationship between evaluation factors and evaluation results, and provide a new effective approach to customer loyalty comprehensive evaluation.

B. The Strategies of Training Customer Loyalty

The key of cultivate long-term customer loyalty is to the customers' personalized values as guidance and create value for customers; the values of different customers may be very different. Specifically, mainly in the following areas to cultivate a sense of customer loyalty:

1) Create more value for customers

Customer Value is the comparing results of the total cost and the total revenue when the customers buy products or services. The total income is more than the total cost; the customer received value is greater. To this end, we can use the value method to analysis the interests and the core needs of the customers. At the same time, in order to gain competitive advantage, the enterprise must be able to create value for its customers more than the competitors. The customers are satisfied with more consumption value, the satisfied customers is only likely to be loyal to a particular enterprise.

2) Allow customers to have a sense of trust

Trust is a prerequisite which the customers have a loyal. On-line, the word trust is particularly important. As the network virtual, the customers and enterprises bargain under the condition of "invisible and intangible" each other, the customers assume a great risk. As a result, the customers tend to maintain long-term relationship with the enterprises which they trust. In fact, while many customers choose and evaluate on-line business, "reliable" is the most important factor, rather than

"cheap" or "a wide range of products." Trust comes from many aspects, such as high-quality products or services, reasonable prices, and so on. And on-line, there are crucial factors: protect the customers' online security, that is, pay on-line security and personal privacy security; performance the contracts timely and accurately; prevent the transactions fraud, and so on.

3) Encourage customers to participate in virtual communities

For businesses, the best customers are those that put forward the representative needs and suggestions to the enterprises, which have advance awareness, interested in work together with enterprises, and then solve the problem jointly. It is very praiseworthy for the enterprises development that has a group of "consultants" and "partnership" customers who never satisfy. On the Internet, create virtual communities where all the customers can communicate and help each other, the customers can put forward good suggestions and views of enterprises' products and services, the enterprises resolve customers' problems on the basis of these proposals, and then design more appropriate products and services for the customers.

4) Shape the customer's personalized needs and shopping experience

With the rising living standards, more and more customers request is raising, the personalized needs turn into the trends gradually. There are different between the personalized production and constitution: Constitution is that, the producer design the products and services according to the customer demand, the customers select the product or service characteristics which they need from a range of menu, and then tell the producers on-line shopping. And the personalized production is a process, which the customers participate in product design and shape needs together with the business. In the network information environment, the enterprises can make use of network technology to communicate directly with customers and explore jointly the product design and production. According to the customers needs, the enterprises design and product the products and services, which enable a high degree of satisfaction with the customers.

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