A study on application of judgment matrix intelligent correction method in satisfaction evaluation

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Abstract

In order to improve rural folk house renovation in the satisfaction evaluation accurately, this paper puts forward a model for rural folk house renovation in the satisfaction evaluation based on intelligent expert judgement matrix adjustment method(AGA-LCAHP).By means of extracting the offset degree resulting in the inconsistency of AHP judgment matrix, this paper puts forward the new method of using accelerating genetic algorithm to locate the element of judgment matrix and calculate the AHP element ranking weight. This algorithm takes offset information as the foundation of correcting judgment matrix to avoid the subjectivity of correction; at the same time, it reserves and extracts the consistency information of judgment matrix, with the consistency index as the orientation of optimization. The case study result shows that the AGA-LCAHP method features high computational accuracy and stable calculation result and also has the popularization and application value in other comprehensive assessment.

Keywords: analytic hierarchy process, judgment matrix, consistency, offset degree, genetic algorithm

1 Introduction

T.L.Saaty et al put forward analytic hierarchy process (AHP) in the 1970's. This method mathematizes the thinking process, quantifies the subjective judgment, quantizes the difference of comparison object, and makes the complex system hierarchical, thus it is a method to make judgment subjective thinking clearer. The key to solve the problem with analytic hierarchy process (AHP) is how to build the judgment matrix. Because there are some unavoidable errors in human judgment, especially in complex system, the given judgment matrix of expert tend to be inconsistent, thus adjusting the given judgment matrix is the usual practice. This turns the test of judgment matrix consistency and how to correct the inconsistent judgment matrix into the key problem of analytic hierarchy process. At present the methods for judgment matrix inconsistency mainly include empirical estimation method, optimal transfer matrix method, vector included angle cosine method, pattern recognition method, induced matrix method. All these are the correction to subjective experience or partial element, which cannot achieve the best correction effect. On the basis of existing accelerating genetic algorithm and correction method of judgment matrix, this paper establishes analytic hierarchy process for locating the correction judgment matrix consistency based on offset information. Genetic algorithm is an algorithm of using coding technology and genetic manipulation to simulate the optimizing search. Compared with non-intelligent optimization method, this algorithm only requires that the problem translated into code can be calculated, and not require whether the solution of problem is limited by linear, continuous, differentiable, noiseless, etc. Therefore, it is widely used in solving multi-dimensional and nonlinear complex optimization problems. This paper regards the correction of inconsistent matrix as a nonlinear optimization problem, which extracts the information of offset degree by using the inconsistency of judgment matrix, conducts location optimization through self-adaption and global optimization function of accelerating genetic algorithm [8], achieves the correction of matrix consistency, and gives the weight of each element of AHP.

2 Accelerating genetic algorithm for correcting judgment matrix consistency in AHP based on offset information.

The LAGA-CAHP calculation procedure is as following:

Step 1: decompose the system to be evaluated into hierarchical model. According to universality, hierarchical structure is divided into three levels from top to bottom, i.e. *A* – objective level, *B* – criterion level and *C* – scheme level. Level *A* is the general objective of evaluation system consisted of one element. Level *B* consists of m criterions for achieving the general evaluation objective, and these criterions weigh the degree that each scheme meets the general objective. Level *C* consists of *n* specific schemes for achieving the general objective. These objectives, criterions and schemes constitute a basic AHP hierarchical model.

Step 2: build the judgment matrix of each level. This includes the judgment matrixes of *B* criterion level and *C* scheme level. Each level of judgment matrix is built with

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the element of last level as the criterion. The judgment matrix of criterion level is built with the general objective as the criterion; if it is necessary to compare the influence of n criterions B_1, B_2,…, B_n, on the general objective *A*, generally adopt pairwise comparison method to generate a pair comparative matrix. Suppose that a_{ij} is the ratio between the influence of Criterion B_i and Criterion B_j on the general subject *A*, the matrix $A=\left(a_{ij}\right)_{n\times n}$ consisted of a_{ij} is called as judgment matrix.

Step 3: test and correct the consistency of each judgment matrix, and calculate the ranking weight. With the weight calculation of Level *B* as example, suppose that single ranking weight of each element of Level *B* is w_k, $k=1,2,...,n$, and $w_k>0$ and $\sum_{k=1}^{n_b} w_k=1$. Based on the definition of judgment matrix, theoretically there should be

$$b_{ij}=\frac{w_i}{w_j},(i,j=1,2,...,n). \tag{1}$$

In practical application, determine the single ranking weight $\{w_k | k=1,2,...,n\}$ of each element through practical judgment matrix $B=\{b_{ij}\}_{n\times n}$. If judgment matrix *B* meets Equation (1), namely that the judgment matrix is consistent, there is a relation as follows:

$$\sum_{i=1}^{n}\sum_{j=1}^{n}\left|b_{ij}w_j-w_i\right|=0. \tag{2}$$

However, because there are some unavoidable errors in human judgment, especially in complex system, the given judgment matrix of expert tend to be inconsistent, namely that the decision maker cannot give an exact comparative result of w_i/w_j. In practical application, most judgment matrixes are inconsistent, thus it is necessary to correct the judgment matrix, till the satisfactory consistency required by AHP is met.

When the judgment matrix is inconsistent, it is necessary to correct original matrix. Based on two hypotheses that most of given judgments of expert are correct and the cognitive ability and judgment basis of experts are roughly the same, this paper puts forward a method of extracting the inconsistency information of judgment matrix based on the logical relation between all information of matrix, and using the inconsistency information to correct.

Suppose that the judgment matrix is $B=(b_{ij})_{n\times n}$, the inconsistency information is extracted according to following steps:

1) First conduct consistency test to expert judgment matrix. If the requirement of consistency is met, stop here; otherwise, please go to Step 2.

2) The indirect judgment information of relative importance of comparing scheme *i* and *j* in expert judgment matrix is ${b^k}_{ij}$. ${b^k}_{ij}=b_{ik}\times b_{kj}$, of which, $k=1,2...n$ and $k\neq i,j$.

For each element of matrix, there are $(n-2)$ indirect logical judgment information $\left({b^k}_{ij}\right)$, from which we can deduce the relative importance of scheme *i* and *j*.

3) The offset degree of each element in judgment matrix is defined as β_{ij}:

$$\beta_{ij}=\sum_{\substack{k=1\\k\neq i,j}}^{n}\frac{(b_{ij}-b_{ij}^k)^2}{(b_{ij})^2}. \tag{3}$$

4) The overall offset degree of each scheme is defined as β_l. The offset degree of overall scheme is the mean value of all elements included in this scheme in the matrix.

$$\beta_l=\left(\sum_{\substack{i=1\\j=l}}^{n}\beta_{ij}+\sum_{\substack{j=1\\i=l}}^{n}\beta_{ij}\right)/(2n+1). \tag{4}$$

5) The overall offset degree of expert judgment matrix is defined as β. The overall offset degree of judgment matrix is the mean value of offset degree of all elements.

$$\beta=\left(\sum_{i=1}^{n}\sum_{j=1}^{n}\beta_{ij}\right)/n^2. \tag{5}$$

Through above analysis, this paper breaks up the inconsistency information of judgment matrix into element offset information, scheme offset information and overall offset information.

Suppose that the correction judgment matrix of original judgment matrix $B=\{b_{ij}\}_{n\times n}$ is $X=\{x_{ij}\}_{n\times n}$, of which X is the value of single ranking weight of each element $\{w_k | k=1,2,...,n\}$, making the minimum matrix X in following formula be the optimal consistency judgment matrix of matrix *B*.

$$\min CIC(n)=\sum_{i=1}^{n}\sum_{j=1}^{n}\left|x_{ij}-b_{ij}\right|/n^2+\sum_{i=1}^{n}\sum_{j=1}^{n}\left|x_{ij}w_j-w_i\right|/n^2, \tag{6}$$

$$s.t \quad x_{ii}=1(i=1,2...n),$$

$$1/x_{ji}=x_{ij}\in\left[b_{ij}-db_{ij},b_{ij}+db_{ij}\right]\cap[1/9,9],$$
$$i=1,2...n,\ j=i+1,i+2...n$$

$$\sum_{i=1}^{n}w_k=1, w_k>0(k=1,2,...,n),$$

where, objective function $CIC(n)$ is called as consistency index coefficient; d is non-negative parameter, which can be selected from $[0, 0.5]$ according to experience; this is a nonlinear programming problem, of which, the single ranking weight $w_k(k=1,2,...,n)$ and the element of correction judgment matrix $X=\{x_{ij}\}_{n\times n}$ are optimization variables, and there are $n(n+1)/2$ independent optimization variables in all. The less the value of Equation (6), the higher the consistency of judgment matrix B. When $CIC(n)=0$, $X=B$, namely that Equations (1) and (2) are established, and judgment matrix B has a complete consistency.

This paper uses the global searching function of accelerating genetic algorithm (*AGA*) to optimize this nonlinear problem. The condition of ending the searching can be that there is satisfactory consistency when $CIC(n)$ value is less than a standard value. When the requirement of satisfactory consistency is not met, we can adjust parameter d and matrix B, till it is satisfactory. The solution of matrix of Level C is the same.

Because it is difficult for the genetic algorithm to adapt to the change of searching space, the computational efficiency is low, and the phenomenon of premature convergence is easy to emerge. This paper uses accelerating genetic algorithm to optimize the consistency index. Suppose that the parameter model to be optimized is:

$$\min f=\sum_{i=1}^{m}\left\|F(C,X_i)-Y_i\right\|^2 \quad (7)$$

$$s.t.\ a_j\le c_j\le b_j,\ j=1,2,...,p$$

Of which, $C=\{c_j\}$ is the p optimized parameters, that is each element in judgment matrix; $[c_j-\beta_{ij}, c_j+\beta_{ij}]$ is the initial change range determined by parameter c_j according to the degree of deviation of element, and the higher the degree of deviation, the larger the range of change; X is the N-dimension input variable of model; Y is the N-dimension output variable of model; F is the nonlinear model determined according to consistency index, i.e. $F:R^N\to R^M$; the value of $\|\ \|$ is norm; f is optimization criterion function.

Step 4: overall ranking level and its consistency test. Successively test the judgment matrix and calculate the weight of each level from the highest level A to the lowest level c. The overall ranking weight of Level C is $w_i^A=\sum_{k}^{n}w_k w_i^k\ (i=1,2,...,n)$ and the consistency coefficient of overall ranking is $CIC^A(m)=\sum_{i=1}^{n}w_k CIC^k(m)$. It is deemed as that there is a satisfactory consistency when it is less than a setting standard value.

Step 5: determine the ranking of each decision scheme according to the overall ranking weight $w_i^A(i=1,2,...,n)$ of each element of Level C.

3 Theoretical analysis of AGA-LCAHP

3.1 JUDGMENT OF THE SATISFACTORY CONSISTENCY OF JUDGMENT MATRIX

If the order of judgment matrix is different, there are different consistency index coefficients of AGA-LCAHP. This paper defines critical random consistency index $LCIC(n)$. This paper constructs 500 order of 3~9 matrixes through stochastic simulation, and these matrixes cannot meet the requirement of consistency, but they meet unit and reciprocity at the same time. On the basis of $LCIC(n)$ analogue data, the 50th data ranked from small to large is taken as the critical value; when $CIC(n)<LCIC(n)$, this judgment matrix is deemed as with satisfactory consistence. $LCIC(n)$ calculated according to analogue data is as shown in following Table 1:

TABLE 1 $LCIC(n)$ Value Calculated According to Analogue Data

Order	**3**	**4**	**5**	**6**	**7**	**8**	**9**
$LCIC(n)$	0.101	0.132	0.176	0.189	0.192	0.199	0.208

This paper introduces consistency test index coefficient $PCIC(n)$ according to the offset information of judgment matrix, and $PCIC(n)$ is defined as:

$$PCIC(n)=\frac{1}{n^2}\sum_{i=1}^{n}\sum_{j=1}^{n}(b_{ij}-b_{ij}^k)^2/2\sigma^2\ . \quad (8)$$

Mathematical derivation proves $PCIC\sim\chi^2(n^2)$, therefore the problem of testing whether judgment matrix has a satisfactory consistency is translated into hypothesis testing problem at the right; the original hypothesis considers that the judgment matrix has satisfactory consistence, namely $H_0:\sigma^2\le\sigma_0^2$. Construct statistics $\chi^2_{PCIC}=\sum_{i=1}^{n}\sum_{j=1}^{n}(b_{ij}-b_{ij}^k)^2/2\sigma^2$, if $\chi^2_{PCIC}>\chi^2_{1-\alpha}(n^2)$, the original hypothesis is refused, or else the judgment matrix is deemed as with satisfactory consistency. This judgment method in this paper is called as consistency χ^2 test method based on offset information $PCIC(n)-\chi^2_\alpha(n^2)$.

The coefficient of consistency test index $LCIC(n)$ and $\chi^2_{1-\alpha}(n^2)$ continuously increase with n, indicating that the larger the order n of judgment matrix, the larger the consistency which can be permitted. Compared with the pure use of $CIC(n)<0.10$ criterion, this method is more flexible. The analogue experiment shows that

$PCIC(n)-\chi_{\alpha}^{2}(n^{2})$ criterion is more stringent than $LCIC(n)$. The proportion of matrix which meets the requirement of consistency under $PCIC(n)-\chi_{\alpha}^{2}(n^{2})$ Criterion and $LCIC(n)$ Criterion is as shown in following Table 2.

TABLE 2 The proportion of matrix

Order	3	4	5	6	7	8	9
$PCIC(n)$	9.72	9.78	9.73	9.81	9.82	9.87	9.91
$LCIC(n)$	9.82	9.86	9.91	9.92	9.92	9.89	9.93

3.2 ROBUSTNESS ANALYSIS

With judgment matrix $C=\{c_{ij}\}_{n\times n}$ as example, suppose that relative rate of change is $a\in[0,1]$, any element of matrix is c_{ij}, there are 200 new c_{ij} randomly generated in $[c_j-\beta_{ij},c_j+\beta_{ij}]\cap[1/9,9]$, this way 200 random judgment matrixes are obtained. Obtain ranking weight through AGA-LCAHP analysis, and by comparing it with ranking weight of original matrix, the analysis result is as follows:

When relative rate of change is set as 10%, the ratio that 200 random vibration matrixes have satisfactory consistency is 0.01, and the coefficient of satisfactory consistency index $PCIC(n)$ is 0.007, it can be considered that all these matrixes have satisfactory consistency. In the view of ranking weight, when relative rate of change is set as 20% and 50% respectively, the difference between ranking weight of these matrixes and original judgment matrix is not large, indicating that the ranking weight calculated with AGA-LCAHP has certain stability.

3.3 COMPARISON BETWEEN AGA-LCAHP AND OTHER CORRECTION AHP METHODS

The methods for correcting judgment matrix mainly include empirical estimation method, optimal transfer matrix method; vector included angle cosine method, pattern recognition method and induced matrix method. When correcting judgment matrix, mainly include following two aspects of problems, one is that the degree of complex of adjusting the algorithm and the calculated amount are large; another one is that the adjustment of algorithm lacks of the use of information of index or scheme, and the orientation of adjusting lacks of theoretical foundation, sometimes it may go against the subjective intention of expert or affected by the logic error of expert. AGA-LCAHP evaluation model put forward in this paper fully extracts the opinion of expert and corrects the logic error of expert based on expert judgment matrix. Directly proceeded with judgment matrix, this method takes the variable of complete consistency index of judgment matrix as the orientation of optimization, thus it is simple and intuitive; with the global searching ability, AGA-LCAHP evaluation model improves the efficiency of searching through accelerating algorithm; Robustness analysis of AGA-LCAHP evaluation model indicates that the calculation result of this method is stable; AGA-LCAHP evaluation model achieves the correction function of location and orientation according to the offset degree information of judgment matrix, making its correction amplitude small and that the ranking result and result of most correction method are similar, therefore it has higher universality and adaptation; AGA-LCAHP evaluation model takes full advantage of the information of judgment matrix to achieve intelligent search and optimization through genetic algorithm, which decreases the computational expense and increases the efficiency of correction.

In the view of ranking weight of judgment matrix, characteristic value method is the frequently used method, but the consistency test and weight calculation of judgment matrix in this method is separate, and the weight and consistency are fully determined by judgment matrix. When the consistency of judgment matrix is poor, it is difficult to determine effective characteristic root; row sum normalization method, column sum inversion method and sum product method is just a kind of approximation algorithm, and its accuracy of calculation is not high; AGA-LCAHP method, logarithm regression method, method of least square and minimum deviation method is a kind of initiative method of using all element information of judgment matrix under the condition of meeting the consistency, they obtain the ranking weight through the optimization to the condition of consistency or optimize the value of consistency by means of changing the weight, therefore these methods have many fine natures such as substitution invariance, compatibility, symmetry and complete harmony. However the weight determined through logarithm regression, method of least square and minimum deviation method is small, it is easy to generate large deviation due to that the weight appears on the denominator, thus the robustness of calculated result is poor. AGA-LCAHP method directly deduces the consistency index coefficient according to the definition of judgment matrix, fully extracts the information of judgment matrix, optimizes in the field of degree of deviation and consistency. Therefore, AGA-LCAHP method is a kind of initiative and intuitive method.

4 Comparative analysis of AGA-LCAHP algorithm example

Example 1. Suppose that the judgment matrix is C_1

$$C_1=\begin{bmatrix}1 & 1/9 & 2 & 1/5\\ 9 & 1 & 5 & 2\\ 1/2 & 1/5 & 1 & 1/2\\ 5 & 1/2 & 2 & 1\end{bmatrix},$$

$$C_1^1 = \begin{bmatrix} 1 & 1/9 & 1/9 & 1/5 \\ 9 & 1 & 5 & 2 \\ 9 & 1/5 & 1 & 1/2 \\ 5 & 1/2 & 2 & 1 \end{bmatrix}.$$

The vector of ranking weight of this matrix is $(0.1450, 0.5433, 0.0853, 0.2264)$ obtained by means of sum product method, and the correction judgment matrix obtained by means of included angle cosine method of the vector of each column and eigenvector of normalization judgment matrix is C_1^1.

The vector of corresponding ranking weight is $(0.0427, 0.5210, 0.1860, 0.2513)$, and the value of consistency index coefficient is $CR = 0.1048$.

The correction matrix obtained by means of induced matrix method is C_1^2.

$$C_1^2 = \begin{bmatrix} 1 & 1/7 & 2 & 1/5 \\ 7 & 1 & 5 & 2 \\ 1/2 & 1/5 & 1 & 1/2 \\ 5 & 1/2 & 2 & 1 \end{bmatrix},$$

$$C_1^3 = \begin{bmatrix} 1 & 0.1429 & 0.5 & 0.2 \\ 7 & 1 & 5 & 2 \\ 2 & 0.2 & 1 & 0.5 \\ 5 & 0.5 & 2 & 1 \end{bmatrix},$$

$$C_1^4 = \begin{bmatrix} 1 & 0.1111 & 0.5 & 0.2000 \\ 9 & 1 & 3 & 2 \\ 2 & 0.3333 & 1 & 0.5000 \\ 5 & 0.5000 & 2 & 1 \end{bmatrix}.$$

The vector of corresponding ranking weight is $(0.1014, 0.5254, 0.0952, 0.2780)$ and the value of consistency index coefficient is $CR = 0.0933$.

Use AGA-CAHP and AGA-LCAHP to correct, the parameter of rate of change is set as 30%, and the initial change interval of each ranking weight is set as $[0,1]$, use AGA accelerating algorithm to calculate 30 times and respectively obtain correction matrix C_1^3 and C_1^4

The vector of corresponding ranking weight is $(0.0643, 0.5345, 0.1237, 0.2776)$ and $(0.0617, 0.5114, 0.1445, 0.2823)$ the value of consistency index coefficient is $CR = 0.0083$ and $CR = 0.0072$ respectively; the consistency obtained by means of accelerating genetic algorithm is maximum and the correction amplitude is minimum. From the comparison between AGA-CAHP and AGA-LCAHP and other correction methods, we can see that the correction amplitude obtained by means of accelerating genetic algorithm is minimum and the consistency is maximum, and for the vector of ranking weight, AGA-CAHP and AGA-LCAHP are similar to other correction methods. From the comparison between AGA-CAHP and AGA-LCAHP we can see that AGA-LCAHP can further improve the level of consistency and decrease the amplitude of correction.

Example 2. Suppose that the judgment matrix is C_2.

$$C_2 = \begin{bmatrix} 1 & 2 & 4 & 1/2 & 2/3 \\ 1/2 & 1 & 3 & 1/3 & 4/9 \\ 1/4 & 1/3 & 1 & 2/9 & 1/9 \\ 2 & 3 & 9/2 & 1 & 1/2 \\ 3/2 & 9/4 & 9 & 2 & 1 \end{bmatrix},$$

$$C_2^1 = \begin{bmatrix} 1 & 1.7896 & 4.0807 & 0.6980 & 0.5087 \\ 0.5588 & 1 & 2.2803 & 0.3900 & 0.2843 \\ 0.2451 & 0.4386 & 1 & 0.1700 & 0.1248 \\ 1.4328 & 2.5642 & 5.8471 & 1 & 0.7290 \\ 1.9656 & 3.5177 & 8.0212 & 1.3718 & 1 \end{bmatrix}.$$

The correction matrix obtained by means of pattern recognition method is C_2^1. The vector of corresponding ranking weight is $(0.1922, 0.1074, 0.0471, 0.2754, 0.3778)$, and the value of consistency index coefficient is $CR = 0.3114$; use AGA-CAHP and AGA-LCAHP to correct, the parameter of rate of change is set as 30%, and the initial change interval of each ranking weight is set as $[0,1]$, use AGA accelerating algorithm to calculate 20 times and respectively obtain correction matrix C_2^2 and C_2^3:

$$C_2^2 = \begin{bmatrix} 1 & 2.001 & 4.0011 & 0.4995 & 0.6657 \\ 0.5000 & 1 & 2.9979 & 0.3332 & 0.4449 \\ 0.2499 & 0.3336 & 1 & 0.2221 & 0.1111 \\ 2.0020 & 3.0012 & 4.5025 & 1 & 0.4995 \\ 1.5022 & 2.2477 & 9.0009 & 2.0020 & 1 \end{bmatrix},$$

$$C_2^3 = \begin{bmatrix} 1 & 2.001 & 4.0011 & 0.4995 & 0.6657 \\ 0.5000 & 1 & 2.9979 & 0.3332 & 0.4449 \\ 0.2499 & 0.3336 & 1 & 0.2221 & 0.1111 \\ 2.0020 & 3.0012 & 4.5025 & 1 & 0.4995 \\ 1.5022 & 2.2477 & 9.0009 & 2.0020 & 1 \end{bmatrix}.$$

The vector of corresponding ranking weight is $(0.2185, 0.1108, 0.0463, 0.2270, 0.3973)$ and $(0.2185, 0.1108, 0.0463, 0.2270, 0.3973)$ respectively, and the value of consistency index coefficient is $CR = 0.0407$ and $CR = 0.0407$ respectively. From the comparison between AGA-CAHP, AGA-LCAHP and pattern recognition method we can see that the correction amplitude of AGA-LCAHP method is minimum, and the consistency is high, and for the vector of ranking weight, the difference between AGA-LCAHP and pattern recognition method is not large.

5 Case studies

Taking the rural folk house renovation in the satisfaction evaluation for example, the paper explores and analyses the relationship between the rural residential building renovation and the energy use condition and villager satisfaction. The paper focuses on studying on the satisfaction of residents in the residence renovation process and the renovation effect and mainly reflects the satisfaction situation in the housing condition, surrounding environment, energy use and government policies, with the specific index system shown in the Figure 1:

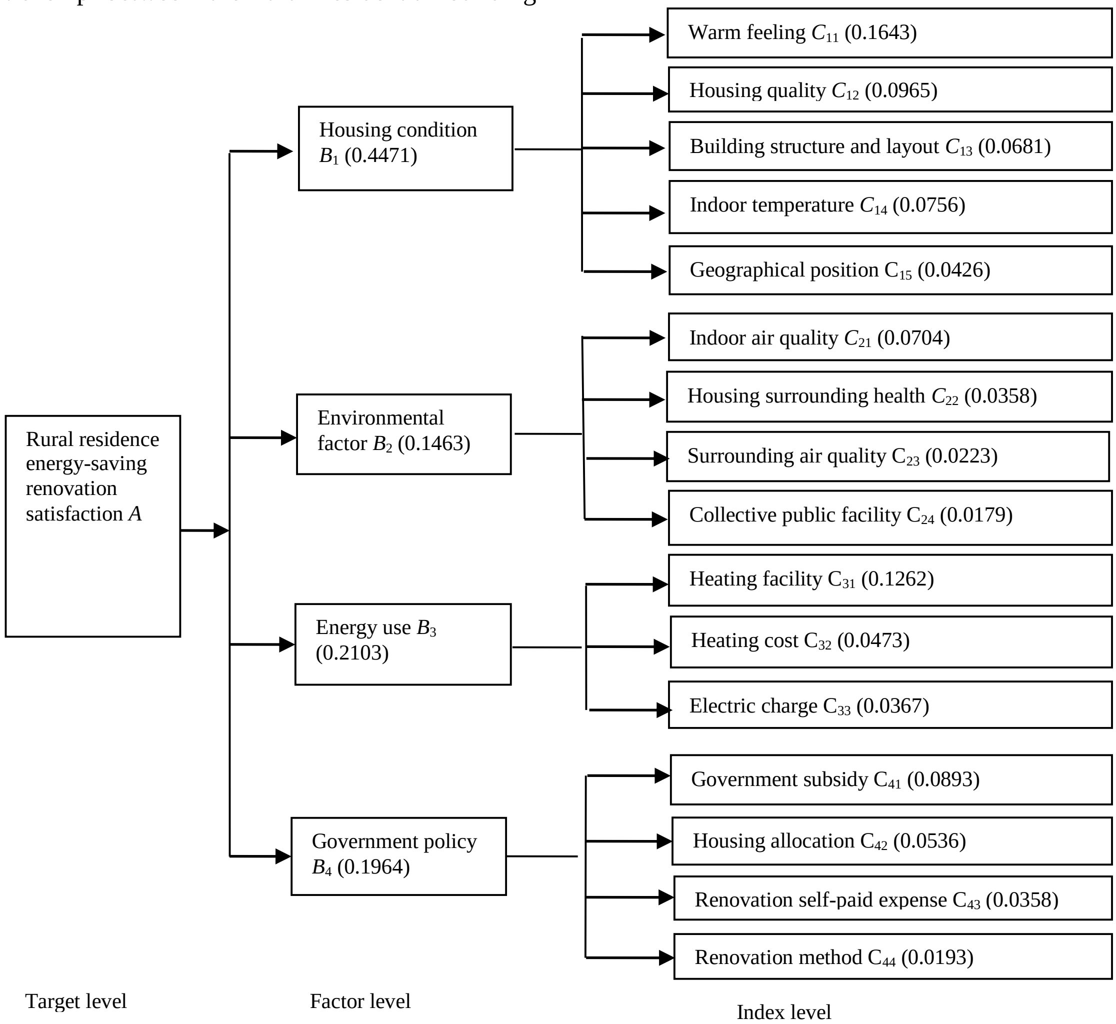

FIGURE 1 Rural residence energy-saving renovation index system and index weight

The judgment matrix in the paper is given out under the general objective of experts, and the direct comparison method is adopted for the importance between indexes to generate the judgment matrix. The paper uses the method of 1-5 ratio scale to quantify the logical judgment of relative importance. The comparison value can be set as 1, 2, 3, 4 and 5, standing for the importance degrees between two indexes, namely equally important, weakly important, obviously important, very important or extremely important, shown in the following Table 3:

TABLE 3 Pairwise Comparison Saaty Scale

Scale	Significance
1	Comparing two elements, the two are equally important
2	Comparing two elements, the first one is weakly important than the second
3	Comparing two elements, the first one is obviously important than the second
4	Comparing two elements, the first is very important than the second
5	Comparing two elements, the first is extremely important than the second
Reciprocals of numerical values	The above comparative result of the two elements

The judgment matrix is reached through interviewing with experts and inviting them to fill in the consultation table. The judgment matrix of the factor level and the target level is $A=\left(a_{ij}\right)_{4\times4}$, and the judgment matrixes of the index level and the factor level are $B_1=\left(b_{ij}\right)_{5\times5}$, $B_2=\left(b_{ij}\right)_{4\times4}$, $B_3=\left(b_{ij}\right)_{3\times3}$, $B_4=\left(b_{ij}\right)_{4\times4}$, shown as follows:

$$A=\begin{bmatrix}1 & 3 & 1 & 1\\ \frac{1}{3} & 1 & 1 & \frac{1}{2}\\ 1 & 1 & 1 & 1\\ \frac{1}{3} & 2 & 1 & 1\end{bmatrix},$$

$$B_1=\begin{bmatrix}1 & 1 & 1 & \frac{1}{2} & \frac{1}{4}\\ \frac{1}{2} & 1 & 1 & 1 & \frac{1}{3}\\ 1 & 2 & 1 & 1 & \frac{1}{2}\\ 2 & 1 & 3 & 1 & 2\\ 4 & 3 & 2 & \frac{1}{2} & 2\end{bmatrix}.$$

$$B_2=\begin{bmatrix}1 & 3 & 4 & 2\\ \frac{1}{3} & 1 & 2 & 3\\ \frac{1}{4} & \frac{1}{2} & 1 & 2\\ \frac{1}{2} & \frac{1}{3} & \frac{1}{2} & 1\end{bmatrix}$$

$$B_3=\begin{bmatrix}1 & 3 & 4\\ \frac{1}{3} & 1 & 1\\ \frac{1}{4} & \frac{1}{2} & 2\end{bmatrix}$$

$$B_4=\begin{bmatrix}1 & 2 & 3 & 5\\ \frac{1}{2} & 1 & 5 & 3\\ \frac{1}{3} & \frac{1}{5} & 1 & 4\\ \frac{1}{8} & \frac{1}{3} & \frac{1}{4} & 1\end{bmatrix}$$

The result of calculating the sorting weight of the above judgment matrixes using AGA-LCAHP is shown in the Table 4:

TABLE 4 The judgment matrix weight comparison of eigenvalue method and AGA-LCAHP method

Method	Judgment matrix	Sorting weight					Consistency index system numerical value
		w_1	w_2	w_3	w_4	w_5	
Eigenvalue method	A	0.406	0.148	0.237	0.208	0.0927	0.0655
AGA-LCAHP	A	0.4471	0.1463	0.2103	0.1964	0.0925	0.0569
Eigenvalue method	B_1	0.3265	0.2348	0.1678	0.1782		0.0591
AGA-LCAHP	B_1	0.3674	0.2158	0.1524	0.1692		0.0452
Eigenvalue method	B_2	0.4763	0.2559	0.1522	0.1156		0.0949
AGA-LCAHP	B_2	0.4812	0.2445	0.1521	0.1222		0.0932
Eigenvalue method	B_3	0.5937	0.2265	0.1798	0.0909		0.0454
AGA-LCAHP	B_3	0.6003	0.2251	0.1746	0.0984		0.0432
Eigenvalue method	B_4	0.4545	0.2727	0.1919			0.1027
AGA-LCAHP	B_4	0.4546	0.2728	0.1822			0.0748

From Table 4, we can see that the computational accuracy of AGA-LCAHP is higher than the calculation result of the eigenvalue method; the global optimization searching can be conducted based on the sorting value interval, and the calculation result is relatively stable; the consistency coefficient average value of judgment matrix after correction is less than 0.1, with satisfying consistency. The weight coefficient of evaluation indexes and evaluation factors is further reached via accelerating genetic algorithm, shown in Table 4. The calculation result shows that the most influential factor sorting of rural folk house renovation in satisfaction evaluation is housing condition B_1, energy use B_3, environment factor B_2 and government policy B_4. By the computation of index weight, the most influential index sorting is warm feeling C_{11}, heating facility C_{31}, housing quality C_{12}, government subsidy C_{41}, indoor Temperature C_{14}, indoor air quality C_{21}, building structure and layout C_{13}, house allocation situation C_{42}, heating cost C_{32}, geographical position C_{15}, electric charge C_{33}, renovation self-paid expense C_{43}, housing surrounding health C_{22}, surrounding air quality C_{23}, renovation method C_{44}, and collective public facility C_{24}. The specific weighted value is shown in the figure. Through the above analysis, we can draw a conclusion that the most influential major factors to rural folk house renovation satisfaction are the heat preservation situation after renovation and the renovation situation of heating equipment and housing quality, so the government can focus on strengthening the renovation effort in heating facilities and housing quality in housing energy-saving renovation, so as to improve residents' satisfaction. The Rural residence energy-saving renovation index system and index weight is shown in Figure 1.

6 Conclusions

Firstly, this paper regards the correction of judgment matrix as a nonlinear optimization problem. AGA-LCAHP evaluation model is a new method of extracting the information of offset degree according to the inconsistency of judgment matrix, locating the inconsistency of correction judgment matrix through accelerating genetic algorithm (AGA) under the guide of information of offset degree, and calculating the ranking weight of each element of judgment matrix.

Secondly, AGA-LCAHP evaluation model put forward in this paper fully extracts the opinion of expert and corrects the logic error of expert based on expert judgment matrix. This method directly deduces the consistency index coefficient according to the definition of judgment matrix, fully extracts the information of judgment matrix, and optimizes in the field of degree of deviation and consistency. Therefore, AGA-LCAHP method is initiative and intuitive. The robustness analysis of AGA-LCAHP evaluation model indicates that the calculation result of this method is stable; evaluation model achieves the correction function of location and orientation according to the information of offset degree of judgment matrix, making its correction amplitude small and that the ranking result and result of most correction method are similar, therefore it has higher universality and adaptation; AGA-LCAHP evaluation model takes full advantage of the information of judgment matrix to achieve intelligent search and optimization through genetic algorithm, which decreases the computational expense and increases the efficiency of correction.

Thirdly, AGA-LCAHP method is a kind of intelligent evaluation method, which calculates the ranking weight of judgment matrix while judging and correcting the consistency of judgment matrix. It provides certain theoretical and practical value for the integration of intelligent method and analytic hierarchy process.

Finally, The difficulty of rural folk house renovation in satisfaction evaluation lies in reasonably confirming the weight of evaluation indexes, so the analytic hierarchy process (AHP) scored by experts is used to confirm the realization process of these weights. The case study result shows that the AGA-LCAHP method features high computational accuracy and stable calculation result and also has the popularization and application value in other comprehensive assessment. The analysis of rural folk house renovation on the satisfaction evaluation result can provide important scientific basis for rural folk house renovation.

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