User experience evaluation method of sports product based on genetic algorithm

Dong Wang*, Xia Liu and Jun Zhuang

Department of Physical Education,
Huaiyin Institute of Technology,
Huai'an, China
Email: dongw@36haojie.com
Email: 854127@qq.com
Email: 7417639@qq.com
*Corresponding author

Abstract: Aiming at the low evaluation accuracy and long evaluation time of traditional sports product user experience evaluation methods, a genetic algorithm based sports product user experience evaluation method is proposed. By constructing a sports product user experience evaluation index decision matrix, various experience evaluation indicators are obtained, the membership value of each experience evaluation index is calculated, and the numerical structure relationship of potential experience indicators is established. The largest characteristic root in the structure relationship is used as the potential experience indicator. Establish different evaluation attribute matrices, calculate attribute parameter weights, construct evaluation models, output initial evaluation results, use genetic algorithm to optimise the initial evaluation results, establish objective optimisation functions, and obtain the optimisation results of objective functions, which are the final evaluation results. The simulation results show that the proposed method has higher accuracy in evaluating the user experience of sports products, and the evaluation time is shorter.

Keywords: genetic algorithm; sports products; user experience; evaluation model.

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Biographical notes: Dong Wang received his Master's degree in Education from Yangzhou University in 2011. Currently, he is a Lecturer in Physical Education Department of Huaiyin Institute of Technology. His research interests include physical education teaching and training.

Xia Liu received her Bachelor's degree in Education from Nanjing Institute of Physical Education in 1994. Now, he is an Associate Professor of Physical Education Department of Huaiyin Institute of Technology. His research interests include physical education teaching and training.

Jun Zhuang received his Bachelor's degree in Education from Nanjing Normal University in 1989. Now, he is an Associate Professor of Physical Education Department of Huaiyin Institute of Technology. His research interests include physical education teaching and training.

1 Introduction

With the continuous development of the sports industry, in the upsurge of national sports, the sporting goods industry has been booming, sports products also continue to adapt to the needs of popularisation and sports products take user experience as the guidance of product design (Du et al., 2019). User experience is a kind of pure subjective feeling established by users in the process of using products, which is not suitable for users with strong subjective feelings (Chen, 2019). With the support of computer technology, the subjective user feelings can be converted into computer data, which is convenient for researchers to improve or optimise products (Lutz, 2019). With the development of the same product in different forms, user experience has become the main theme of the product society, and gradually derived a variety of evaluation methods.

From the essence of user experience, the users of sports products have few target customers. When investigating the subjective experience of usability, they are easily affected by a variety of external and objective factors. At this time, the results of user experience have some differences, but they also contain close relevance. According to the user experience of sports products, an evaluation method is designed. In foreign countries, the construction of experience evaluation method started earlier. Since the concept of user experience was put forward in the 1990s, statisticians have set a variety of user experience indicators for the same product, and constructed a variety of evaluation methods according to the data collected by experience indicators. At present, the way of collecting user experience is relatively single, and the experience evaluation method is still in the development stage. Li et al. (2020) proposed the evaluation method for user experience of sports products based on quality concept. Based on the USE scale, it constructed the evaluation index system of user experience including effectiveness, ease of use, ease of learning and satisfaction. Using Taguchi's loss function, it transformed the measurement value of each index into Taguchi's loss value. According to the demand preference of sports product users, the weight value of each evaluation index was obtained. According to the weight value, the Taguchi loss value of each index was integrated into the total Taguchi loss value. Finally, the sports products were sorted according to the total Taguchi loss value. Based on this, the design principles of sports products were discussed. A sports product was taken as an example to verify the results. This method is correct and feasible, which can evaluate the robustness of the user experience of sports products, and has certain significance for the design of sports products. Zhang et al. (2019) proposed a method to evaluate the user experience of sports products based on the perceptual needs of users. Firstly, the composite perceptual images in Kansei engineering were introduced to quantify the emotional information of users. Through cluster analysis and principal component analysis of the collected sports product images, the representative target images were generated, and the evaluation values of representative images were obtained by semantic difference survey; secondly, the entropy weight of the standardised image evaluation value was calculated. Finally, the priority of product design alternatives under the guidance of sports product users' emotional information was generated by combining grey correlation analysis and fuzzy TOPSIS. Taking sports smart watch design as an example, the feasibility and effectiveness of the method were verified. Information entropy and fuzzy TOPSIS combined with grey relational analysis can greatly reduce the individual subjective influence in scheme evaluation, ensure the accuracy of evaluation results and have guiding significance for enterprise product scheme decision-making. Lan and Liu (2020) proposed a method based on user experience evaluation of sports products. Firstly, four characteristic indexes affecting the user experience of sports products were extracted, namely, high efficiency, perceptual intelligence, scene driving force and personalisation. Then, according to the four characteristic indexes extracted, the index weight was calculated. Finally, based on the calculation results, the index weight was calculated. This paper used artificial intelligence technology to build the evaluation model of sports product user experience, completed the evaluation design of sports product user experience based on artificial intelligence and further looked forward to the research trend of sports product user experience driven by artificial intelligence, as well as the opportunities brought by artificial intelligence technology for product user experience in the future. However, the evaluation accuracy of the above three methods is low and the evaluation time is long.

In view of the problems of the above methods, this paper proposes a user experience evaluation method of sports product based on genetic algorithm. Genetic algorithm is a highly parallel, random and adaptive optimisation algorithm, which can get the optimal solution of the problem. The application of genetic algorithm improves the evaluation accuracy and shortens the evaluation time. The specific technical route of this paper is as follows:

1) The user experience data of sports product are searched, to construct the decision matrix of user experience evaluation index of sports product and obtain the experience evaluation index;

2) According to the above evaluation indexes of user experience of sports products, the corresponding membership value is calculated and the confirmatory factors in the value set are obtained to construct the numerical structure relationship of potential experience indexes;

3) Taking the largest eigenvalue in the numerical structure relationship of potential experience index as the interference value of potential experience index, different evaluation attribute matrices are established, and the weight of attribute parameters is calculated. According to the obtained attribute weight coefficient, the user experience evaluation model of sports product is constructed, and the initial user experience evaluation results of sports product are output. Genetic algorithm is used to optimise the initial user experience evaluation results of sports product, and the objective optimisation function of the initial evaluation results is constructed by genetic algorithm. The optimisation result of the objective function is the final user experience evaluation result of sports product.

2 Evaluation method for user experience of sports product

2.1 Acquisition of user experience evaluation index of sports product

When searching for sports product user experience index data, continuously input sports product user experience parameters, including product quality, product appearance, product recommendation, brand effect, preference, etc. (Nascimento et al., 2019), and the sports product user experience parameters entered above are impacts the customer satisfaction factor, the simulated experience parameter is a numerical space and a mathematical model is used to describe the processing process, which can be expressed as:

$$SG = \Phi \frac{CE \sum_{i=1}^{N} M_i}{\Gamma} \tag{1}$$

where M_i represents the i function of experience value, C represents the individual coding parameter of the experience data, E represents the experience fitness parameter, Φ represents the selection operator and Γ represents the crossover operator of the algorithm (Mizuma and Takei, 2020).

The user experience parameters obtained from the above mathematical model are regarded as the population and defined as the initial experience data population, which is expressed as:

$$u = \begin{cases} \dfrac{x - a_1}{a_i - a_q}, & a_q < x < a_i \\ 0, & x > a_q \end{cases} \tag{2}$$

where a_i, a_q and a_1 are triangular fuzzy parameters, u is membership function and x is membership parameter. In order to enhance the significance of user experience data, the membership function operation mode is constantly changed and a decision matrix of sports product user experience evaluation index is constructed. The expression of the decision matrix D is as follows:

$$D = \begin{pmatrix} u_{11} & u_{12} & \cdots & u_{1n} \\ u_{21} & u_{22} & \cdots & u_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ u_{m1} & u_{m2} & \cdots & u_{mn} \end{pmatrix} \tag{3}$$

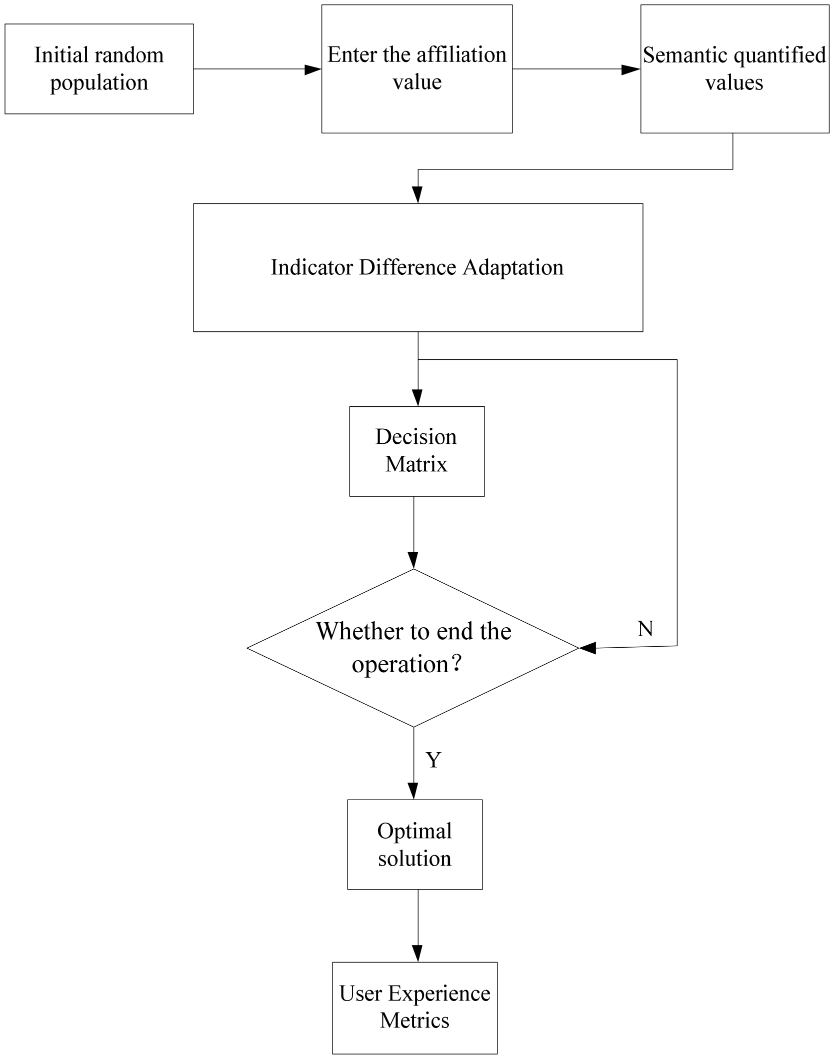
where m represents the value of the dimension corresponding to the decision index, and the meaning of the other parameters is unchanged. The output membership degree obtained from the above matrix is take b as the standard, the one with membership value greater than 1 as the user experience index directly available, and the other indicators of membership value as external influence index (Luo et al., 2021). The output process of the indicators formed is shown in Figure 1.

In the index output process shown in Figure 1, the remaining membership corresponding indexes are described as experience variables, and the iterative output process is repeated to obtain the user experience evaluation index of sports product (Sekerand Aydin, 2020). The expression is as follows:

$$y_N = \frac{1}{L} \sum_{g=1}^{L} u_g f(t) \tag{4}$$

where L represents the number of remaining experience variables, and u_g represents the membership function relationship between the remaining experience variables (Kumar et al., 2020).

Figure 1 The output process of the formed index



2.2 Construction of numerical structure relationship of potential experience index

The evaluation indexes of sports product user experience are summarised, to construct the numerical structure relationship of potential experience indexes. Firstly, according to the user experience evaluation index of sports products, the membership value of the index is calculated (Vale et al., 2019) and the confirmatory factor in the value set is obtained. The calculation formula can be expressed as follows:

$$F = \frac{X_1 - X_2}{\sum_{i=1}^{L} D} \tag{5}$$

where F is the confirmatory factor, X_1 and X_2 are the membership value sets under different processing periods, and the meaning of other parameters remains unchanged. According to the calculated values, the potential variables corresponding to different confirmatory factor values are obtained. The results are shown in Table 1.

Table 1 Potential variables corresponding to different values of confirmatory factors

Confirmatory factor values	*Corresponding latent variable*	*Observation level*
0.753	Try to expect	A1
0.802		A2
0.782	Perceived risk	D4
0.778		D6
0.791	Service quality	C1
0.843		C5
0.813	Willingness of information interaction	G2
0.876		G3
0.753	Information interaction behaviour	H1
0.802		H5
0.782	Information quality	F4
0.778		F6
0.791	social influence	E3
0.843		E4
0.813	Performance expectation	B2
0.876		B4

Corresponding to the latent variable names in the above table, the verification factors of different observation levels are normalised (Yao et al., 2019) and the processing process can be expressed as follows:

$$b_g = \frac{F}{\sum_{i=1}^{8} b_i} \tag{6}$$

where b_g normalises the processing function, b_i represents the latent variable function relationship and the meaning of other parameters remains unchanged. After regularisation, the numerical structure relation K_h (Do et al., 2019) of potential experience index is constructed. The expression is as follows:

$$K_h = \sum_{h=1}^{8} b_g h \tag{7}$$

where h is the number of latent variables in an evaluation process, and the meaning of other parameters remains unchanged.

2.3 Optimisation of user experience evaluation of sports product based on genetic algorithm

Because the user experience has strong subjective will, in order to eliminate the interference caused by subjective will, the largest eigenvalue in the numerical structure relationship of the above potential experience index is taken as the interference value of the potential experience index. The characteristic root can be calculated as follows:

$$\lambda_{\max} = \sum_{i=1}^{n} \frac{FK_h}{y_N w_i} \tag{8}$$

where w_i is the expert evaluation function, $\lambda_{\max}$ is the characteristic root of the interference value of the experience index, and the meaning of other parameters remains unchanged (Kang, 2020).

The eigenvalue value of the interference value of the above experience index is taken as a fixed parameter. When constructing the experience evaluation model, the entropy weight method is used to process the fixed parameter, and the interference degree of external data is determined according to the value, and the fixed value is taken as the entropy parameter (Shirazi et al., 2019). The potential and apparent use experience indicators are summarised as a processing data set, and the probability of significant indicators in the data set is calculated, which can be expressed as:

$$S = \frac{-K\sum_{o=1}^{N} \lambda_{\max}}{r} \tag{9}$$

where r is the normal number and K is the uncertainty. When the probabilities of the saliency of user experience information are equal, different evaluation attribute matrices are constructed based on the above probability parameters. The matrix can be expressed as:

$$M = \begin{array}{c} K_1 \\ K_2 \\ \vdots \\ K_m \end{array} \begin{bmatrix} S_{11} & S_{12} & \cdots & S_{1n} \\ S_{21} & S_{22} & \cdots & S_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ S_{m1} & S_{m2} & \cdots & S_{mn} \end{bmatrix} \tag{10}$$

where M represents decision attribute, m and n all represent the number of experience data participating in evaluation, and the meaning of other parameters is unchanged (Bansal and Ganesan, 2019). For the parameters in the above attribute matrix, the contribution g_{ij} generated by the attribute parameters can be expressed as follows:

$$g_{ij} = \frac{x_{ij} M}{\sum_{i=1}^{m} x_{ij}} \tag{11}$$

where x_{ij} is the value of the parameter function in the attribute matrix, and the meaning of other parameters remains unchanged (Kroll and Weisbrod, 2020). Corresponding to all the values in the attribute matrix, the total contribution of experience evaluation index is calculated, which can be expressed as:

$$E_j = -\frac{K}{\sum_{i=1}^{m} \ln\left(g_{ij}\right)} \tag{12}$$

In the above expression, E_j represents the total contribution value of the attribute, and the meaning of other parameters remains unchanged. According to the above formula, the weight of attribute parameters is calculated and the attribute weight coefficient is obtained.

$$W_j = \frac{E_j}{\sum_{i=1}^{m} d_j} \tag{13}$$

where W_j is the attribute weight coefficient and d_j is the consistency parameter of the evaluation index (Yazdani et al., 2020).

According to the attribute weight coefficient obtained above, the evaluation model of sports product user experience is constructed and the initial evaluation results of sports product user experience are output. The calculation process is as follows:

$$R = \frac{\operatorname{cov}(a,b)}{\sigma a \sigma b W_j} \tag{14}$$

where R is the evaluation result, $\operatorname{cov}(a,b)$ is the covariance between the two evaluation indexes and σa and σb are the variance values between the two indexes (Liu et al., 2019).

In order to ensure the effectiveness of the evaluation results, genetic algorithm is used to optimise the initial user experience evaluation results of sports product. The objective optimisation function of the initial evaluation results is constructed by genetic algorithm, and the optimisation result of the objective function is the final user experience evaluation result of sports product.

Genetic algorithm is a kind of global search algorithm based on genetic mechanism. It combines mathematics and biological evolution process, and assumes that the calculation process of the answer to the question is the biological evolution process. It is a kind of the latest calculation method, its randomness. The advantage is conducive to the calculation of complex problems, and the correct answer can be calculated accurately and quickly. This kind of algorithm has a strong global optimisation selection mechanism, which can avoid the interference caused by the local minimum to the processing result, has strong robustness, and ensures the convergence of the algorithm. It is often used to solve nonlinear programming problems with constraints, so as to accurately calculate feasible solutions for such problems. Therefore, this article uses genetic algorithms to optimise the initial user experience evaluation results of sports products. The specific steps are as follows.

- *Step 1*: set the number of chromosomes in the initial population $NIND$ to NP;
- *Step 2*: cross the chromosomes;

- *Step 3*: after completing the crossover operation, transmit it to the mutation operation model for mutation processing;
- *Step 4*: calculate the fitness function of all chromosomes;
- *Step 5*: set the number of iterations and carry out iterative calculation to find the approximate global optimal chromosome;
- *Step 6*: end the calculation.

Firstly, the number of chromosomes in the initial population $NIND$ of user experience data of sports products is set as NP, and the fitness function of user experience data of sports products is calculated by mutation processing after cross operation. It can be expressed as:

$$f(t) = \frac{SG\sum_{i=1}^{3}|p_t|}{R_i} \tag{15}$$

where p_t is the semantic value of user experience value and R_i is the quantitative value relationship of different sports product types.

According to the fitness function obtained above, after multiple iterative calculations, the initial user experience evaluation results of sports products are optimised, and the objective optimisation function of the initial evaluation results is constructed, that is, the engineering problem is transformed into a mathematical optimisation problem and the objective function is obtained. The optimisation result is the final user experience evaluation result of sports products, and its expression is:

$$Q = \frac{W_j'}{b_{ij}} f(t) \tag{16}$$

where b_{ij} is the index function of large correlation.

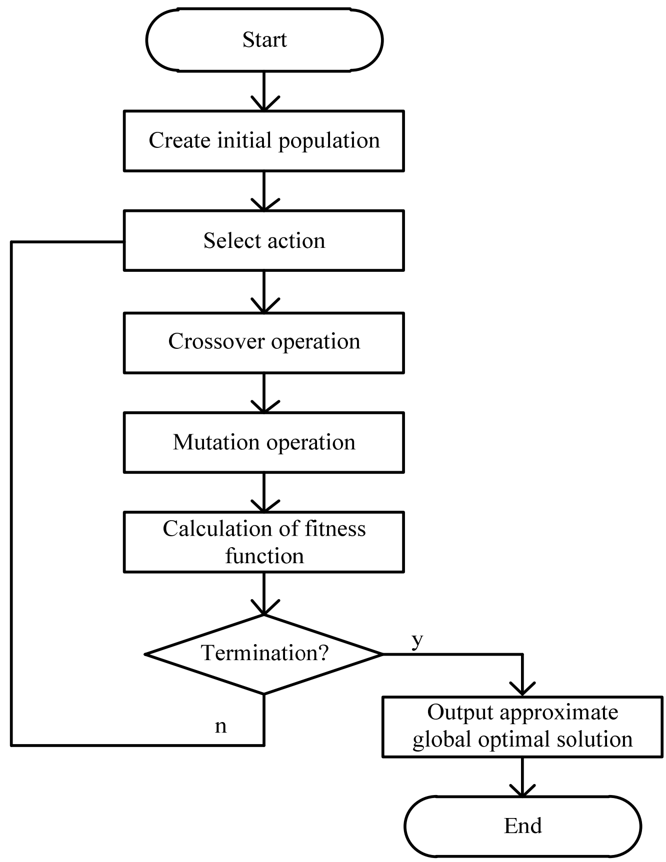
The user experience evaluation process of sports product based on genetic algorithm is shown in Figure 2.

3 Simulation experiment analysis

3.1 Experimental scheme

In order to verify the effectiveness of the user experience evaluation method of sports product based on genetic algorithm proposed in this paper, the user experience evaluation method of sports product based on quality concept proposed in Li et al. (2020) and the user experience evaluation method of sports product based on user perceptual demand proposed in Zhang et al. (2019) are used as comparison methods. Taking the evaluation accuracy and evaluation time as the experimental indexes, a simulation experiment is carried out.

Figure 2 User experience evaluation process of sports product based on genetic algorithm



3.2 Experimental environment

The main environment and tools of the experiment are as follows:

(1) *The hardware environment of the experiment*:

CPU: Intel T7230 1.87Hz

Memory: 2GB

(2) *The software environment of the experiment*:

Software model: Windows XP

Programming information language: Java

Programming development tool: JDKI.G

As a programming language with a wide range of applications, the programming language selected in this article has strong versatility and safety, can ensure the stability of the experimental operation process, improve the accuracy of the simulation experiment and make the obtained experimental results reliable Degree increased. The selected development tools provide a good integrated development environment for the programming language.

3.3 Experimental data

The existing sports products on the market are collected, to formulate the evaluation indexes according to the sports items corresponding to the sports products. The designated sports items and the evaluation indexes are shown in Table 2.

Table 2 Sports name and evaluation index

Serial number	*Sports name*	*Name of evaluation index*
1	speed skating	identity
2	sprint	influence
3	Weightlifting	expect
4	Shot-put	appearance
5	heel-and-toe walking race	cheerful
6	Swimming	recommend
7	Skating	brand
8	Artistic Gymnastics	extend
9	Shooting	preference
10	Table Tennis	comfortable
11	Basketball	/

Under the sports items and the developed index names shown in the above table, the products corresponding to different sports items will be scored and evaluated according to the scores of 1–10. A total of 500 sets of scoring results will be counted, and the best evaluation index will be selected as the initial Simulation parameters. Corresponding to the indicators shown in the above table, in order to support the operation of genetic algorithm, a software technology framework supporting the evaluation process is built. The framework structure of the software technology is shown in Figure 3.

In the framework structure of software technology shown in Figure 3, the upper computer is used to carry the technology framework. When running the genetic algorithm, the texture characteristics and semantic relationship of the corresponding output products of sports products are fitted. The fitting process of the experience characteristics and semantic relationship of sports products is shown in Figure 4.

In the relationship fitting process shown in Figure 4, the initial parameters of the genetic algorithm are set, and the product user data collected by iteration are processed. After processing, comparative experiments are carried out by using the user experience evaluation method of sports product based on quality concept proposed in Li et al. (2020) and the user experience evaluation method of sports product based on user perceptual demand proposed in Zhang et al. (2019) and the user experience evaluation method of sports product based on genetic algorithm proposed in this paper to compare the performance of the three evaluation methods.

Figure 3 Framework of software technology

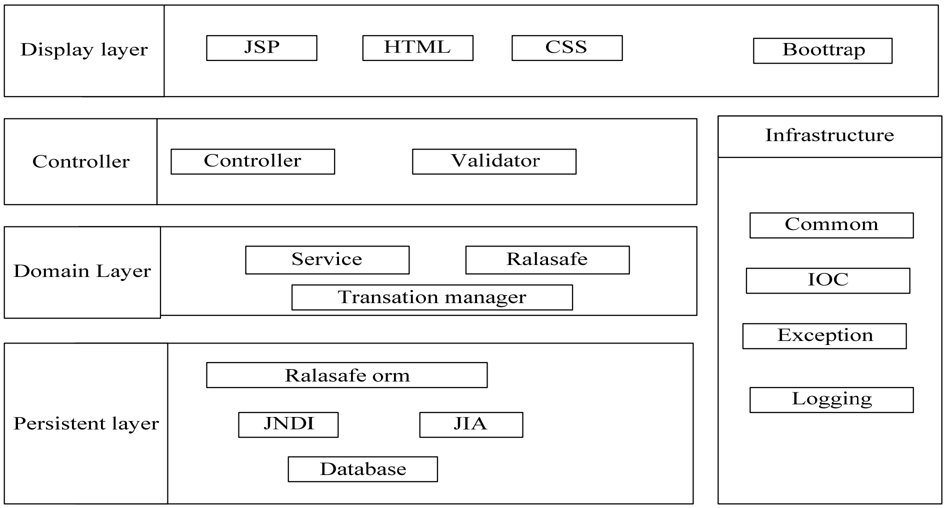
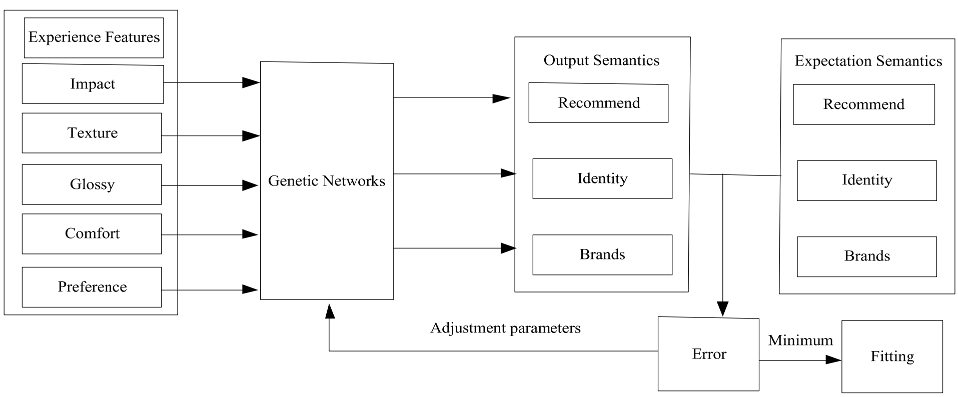


Figure 4 Fitting process of sports product experience characteristics and semantic relationship



3.4 *Performance index*

(1) *Evaluation accuracy*: in the past, the accuracy is mainly reflected in the accuracy rate and recall rate, but these are two different aspects of the two split quality. Therefore, in order to better evaluate the accuracy, it is necessary to consider the two together and not to be biased. Therefore, a new evaluation index FI-test value is generated. The formula is as follows:

$$FI = \frac{N_1 + N_2}{N_1 \cdot N_2} \tag{17}$$

In the formula, N_1 is the accuracy rate and N_2 is the recall rate. The larger the comprehensive FI-test value is, the better the evaluation effect of this method is, otherwise, the worse the evaluation effect is.

(2) *Evaluation time*: This paper selects four data groups as the evaluation objects, a total of 20 processing objects, and takes the user experience evaluation time of sports product as the experimental index to verify the evaluation efficiency of the three evaluation methods. The shorter the evaluation time is, the higher the evaluation efficiency of the method is, on the contrary, the lower the evaluation efficiency is.

3.5 Test and analysis of performance index

3.5.1 Comparison results of evaluation accuracy

This paper uses the user experience evaluation method of sports product based on genetic algorithm, the method of Li et al. (2020) and the method of Zhang et al. (2019) to test the user experience evaluation accuracy of sports product, and the test results are shown in Table 3.

Table 3 Test results of evaluation accuracy

Number of experiments	*FI-test value*		
	Method of this article	*Li et al. (2020) method*	*Zhang et al. (2019) method*
10	95.68%	50.33%	82.4%
20	96.22%	54.35%	84.64%
30	97.30%	55.37%	86.32%
40	98%	54.68%	80%
50	93.56%	56.77%	85.33%
60	99.99%	53.32%	88%
Mean value	97%	54.14%	84.4%

It can be seen from Table 3 that the average FI-test value of the user experience evaluation method of sports product based on genetic algorithm proposed in this paper is 97%, while the average FI-test value of the evaluation method of Li et al. (2020) and Zhang et al. (2019) is 54.14% and 84.4%, respectively and the FI-test average value of the user experience evaluation method of sports product based on genetic algorithm proposed in this paper is higher than the FI-test average value of the user experience evaluation method of sports product based on Li et al. (2020) and Zhang et al. (2019), which indicates that the user experience evaluation accuracy of sports product based on genetic algorithm proposed in this paper is higher and the evaluation effect is good.

3.5.2 Comparison results of evaluation time

By using the methods of Li et al. (2020); Zhang et al. (2019) and this paper, the time required for different data sets to be evaluated on the upper computer is measured. Finally, the response time results of the three experience evaluation methods are shown in Table 4.

Table 4 Comparison results of response time of three experience evaluation methods

Evaluation indicator dataset name	*Response time results/s*		
	Methods of Li et al. (2020)	*Methods of Zhang et al. (2019)*	*Method of this paper*
01-01	8.12	6.02	3.73
01-02	8.26	6.31	3.35
01-03	8.97	6.09	3.17
01-04	8.67	6.86	3.93
02-01	8.29	6.99	3.46
02-02	8.47	6.09	3.42
02-03	8.74	6.95	3.18
02-04	8.63	6.11	3.64
03-01	8.39	6.27	3.59
03-02	8.66	6.95	3.12
03-03	8.93	6.26	3.67
03-04	8.53	6.05	3.13
04-01	8.54	6.52	3.33
04-02	8.01	6.85	3.51
04-03	8.84	6.33	3.73
04-04	8.59	6.94	3.85
05-01	8.79	6.71	3.16
05-02	8.65	6.08	3.67
05-03	8.18	6.26	3.58
05-04	8.09	6.51	3.24

According to the results of response time shown in the above table, the average response time of the method in Li et al. (2020) is about 8.5 s, the actual response time is the longest; the average response time of the method in Zhang et al. (2019) is about 6.4 s, the processing time is longer; and the average response time of the experience evaluation method designed in this paper is about 3.4 s. Compared with the two reference methods, the evaluation time of this method is the shortest.

4 Conclusions

As a new concept, user experience develops rapidly and is gradually applied to sports products. Taking the product experience results as the guidance of sports product design, the user experience evaluation method of sports product based on genetic algorithm is proposed. By searching the user experience data of sports products, the decision matrix of user experience evaluation index of sports products is constructed and the hierarchy of indicators is divided. The relationship between the calculated membership degree and the numerical structure of potential experience index is constructed to obtain the maximum feature root. The maximum feature root is taken as the interference value of potential experience index, and the weight of attribute parameters is calculated. According to the weight coefficient, the maximum feature root is used as the interference value of potential experience index. The user experience evaluation model of sports products is constructed, to output the initial evaluation results. The optimisation objective function is constructed by genetic algorithm to optimise the initial evaluation results, and the final optimisation evaluation results are obtained to realise the evaluation of the user experience of sports products. The simulation results show that, compared with the traditional evaluation method, the evaluation method in this paper has better evaluation effect and good application prospects, and can provide high-quality service for the product experience. We hope this research can provide some value reference for the related research. This method has the following advantages:

1) The average FI-test value of the user experience evaluation method for sports product based on genetic algorithm is 97%. The user experience evaluation accuracy of the sports product is higher and the evaluation effect is better.
2) The average response time of using the user experience evaluation method of sports product based on genetic algorithm in this paper is about 3.4 s, the time is short and the evaluation efficiency is high.

References

Bansal, S. and Ganesan, G. (2019) 'Advanced evaluation methodology for water quality assessment using artificial neural network approach', *Water Resources Management*, Vol. 33, No. 9, pp.3127–3141.

Chen, X. (2019) 'Marine transport efficiency evaluation of cross-border e-commerce logistics based on analytic hierarchy process', *Journal of Coastal Research*, Vol. 94, No. 1, pp.682–682.

Do, T.D., Sommer, C.M. and Melzig, C. et al. (2019) 'A novel method for segmentation-based semiautomatic quantitative evaluation of metal artifact reduction algorithms', *Investigative Radiology*, Vol. 54, No. 6, pp.365–373.

Du, S., Li, H. and Sun, B. (2019) 'Hybrid Kano-fuzzy-DEMATEL model based risk factor evaluation and ranking of cross-border e-commerce SMEs with customer requirement', *Journal of Intelligent and Fuzzy Systems*, Vol. 37, No. 6, pp.8299–8315.

Kang, T. (2020) 'Rule-based LEED evaluation method considering BIM linkage and variability', *KSCE Journal of Civil Engineering*, Vol. 24, No. 1, pp.110–121.

Kroll, E. and Weisbrod, G. (2020) 'Testing and evaluating the applicability and effectiveness of the new idea-configuration-evaluation (ICE) method of conceptual design', *Research in Engineering Design*, Vol. 31, No. 4, pp.1–20.

Kumar, U., Sahoo. B. and Chatterjee, C. et al. (2020) 'Evaluation of simplified surface energy balance index (S-SEBI) 'method for estimating actual evapotranspiration in Kangsabati reservoir command using Landsat 8 Imagery', *Journal of the Indian Society of Remote Sensing*, Vol. 48, No. 10, pp.1421–1432.

Lan, Y. and Liu, S. (2020) 'Review of product user experience research based on artificial intelligence technology', *Packaging Engineering*, Vol. 438, No. 24, pp.33–40.

Li, Y., Zhou, J. and Zhu, L. (2020) 'Research on user experience evaluation of electronic products for the elderly based on Taguchi quality concept', *Machine Design*, Vol. 364, No. 2, pp.136–142.

Liu, W., Tan, R. and Cao, G. et al. (2019) 'A proposed radicality evaluation method for design ideas at conceptual design stage', *Computers and Industrial Engineering*, Vol. 132, pp.141–152.

Luo, X., Ge, Z. and Zhang, S.G. et al. (2021) 'A method for the maintainability evaluation at design stage using maintainability design attributes', *Reliability Engineering [?] System Safety*, Vol. 210, No. 11.

Lutz, S.U. (2019) 'The European digital single market strategy: local indicators of spatial association 2011–2016', *Telecommunications Policy*, Vol. 43, No. 5, pp.393–410.

Mizuma, T. and Takei, A. (2020) 'Performance evaluation of parallel finite element eddy-current analysis using direct method as subdomain solver', *IEEE Transactions on Magnetics*, pp.1–1.

Nascimento, F.P., Souza, M. and Costa, G. et al. (2019) 'Modeling of the Asphaltene Onset Pressure from few experimental data: a comparative evaluation of the hirschberg method and the cubic-plus-association equation of state', *Energy and Fuels*, Vol. 33, pp.3733–3742.

Seker, S. and Aydin, N. (2020) 'Sustainable public transportation system evaluation: a novel two-stage hybrid method based on IVIF-AHP and CODAS', *International Journal of Fuzzy Systems*, Vol. 22, No. 1, pp.257–272.

Shirazi, A.M., Zomorodian, Z.S. and Tahsildoost, M. (2019) 'Techno-economic BIPV evaluation method in urban areas', *Renewable Energy*, Vol. 143, pp.1235–1246.

Vale, G., Fernandes, E. and Figueiredo, E. (2019) 'On the proposal and evaluation of a benchmark-based threshold derivation method', *Software Quality Journal*, Vol. 27, No. 1, pp.275–306.

Yao, K., Wu, L.B. and Wang, Y.S. (2019) 'Nondestructive evaluation of contact damage of ferromagnetic materials based on metal magnetic memory method', *Experimental Techniques*, Vol. 43, No. 3, pp.273–285.

Yazdani, M., Tavana, M. and Pamučar, D. et al. (2020) 'A rough based multi-criteria evaluation method for healthcare waste disposal location decisions', *Computers and Industrial Engineering*, Vol. 143. Doi: 10.1016/j.cie.2020.106394.

Zhang, L., Li, J., Zhao, Y. and Tian, Z. (2019) 'Evaluation method of product design scheme based on users' perceptual needs', *Operation Research and Management*, Vol. 28, No. 1, pp.152–157.