Research on layout optimisation of human-computer interaction interface of electronic music products based on ERP technology

Jing Han

College of Music and Dance,
Henan Normal University,
Xinxiang 453000, Henan China
Email: jinghan@36haojie.com

Abstract: Aiming at the problems of low-user satisfaction and long optimisation time existing in traditional methods, an ERP based human-computer interaction interface layout optimisation method for electronic music products was proposed. ERP technology is used to design the electronic music human-computer interaction interface layout optimisation framework. Support of the architecture using the G_1 method is taken to determine the human-computer interaction interface to the importance of the goal on the layout, combined with the judgment. Results are expected to achieve the optimal layout of visual attention allocation as the objective function, and the layout of the building based on visual attention allocation optimisation model and particle swarm optimisation is used to solve the model and the layout optimisation results are obtained. Experimental results show that only less than 0.3% of users are dissatisfied with the system, and the optimisation time is less than 300 ms, indicating high-user satisfaction and short optimisation time.

Keywords: ERP technology; electronic music products; human-computer interaction; interface layout; layout optimisation.

Reference to this paper should be made as follows: Han, J. (2023) 'Research on layout optimisation of human-computer interaction interface of electronic music products based on ERP technology', *Int. J. Product Development*, Vol. 27, Nos. 1/2, pp.126–139.

Biographical notes: Jing Han received her Doctoral degree majoring in Chorus Conducting from Hanshi University, Korea in July 2019. Currently, she is a Lecturer in College of Music and Dance, Henan Normal University. Her research interests include piano playing and teaching, chorus conducting.

1 Introduction

With the rapid development of social economy, various types of electronic music products have appeared in the market. In addition, consumers' performance requirements for electronic music products are constantly improving, and the performance of electronic music products is in urgent need of optimisation (Turchet and Barthet, 2019). At present, artificial intelligence technology has been widely used in the design process of electronic music products to promote the intellectualisation of electronic music products. However, in the layout process of human-computer interaction interface of electronic music products, due to unreasonable layout and poor applicability, consumer satisfaction continues to decline (Liu, 2019). Therefore, the research on the layout optimisation of human-computer interaction interface of electronic music products can improve product performance and stimulate consumers' purchase desire. Therefore, it is of great research significance to study a method for the layout optimisation of human-computer interaction interface of electronic music products (Shank et al., 2020).

In Kang et al. (2020), to electronic music product interface layout design problems such as the randomness and uncertainty of big, put forward a kind of electronic music products human-computer interaction interface layout multi-objective optimisation methods, this method is designed with the principle of ergonomics and layout beauty degree evaluation criteria as the basis, establishes a hierarchy, relevance, simplicity and comfort the page layout of the basic principles, To build electronic music human-computer interaction interface layout optimisation model and USES genetic algorithm to solve the model, to realise the human-computer interaction interface layout of electronic music products multi-objective optimisation, but the method in the design process is not the user satisfaction as the key to consider, resulting in a decline in the satisfaction of the user to the optimisation result. Han and Zhao (2018) aiming at the problem of low user satisfaction existing in the existing methods, a mathematical statistics based human-computer interaction interface layout optimisation method for electronic music products was proposed. Based on the results of questionnaire survey, this method found that most people thought that the menu design of mobile phone, the layout of the original factory was unreasonable, the operation was cumbersome, the additional functions were unclear, and the practical functions were lacking. The results of questionnaire survey were used to adjust the layout of the interactive interface of electronic music products, and the ant colony algorithm was used to optimise the layout adjustment results. In this way, the layout of the human-computer interaction interface of electronic music products is optimised. However, the authenticity and clarity of the human-computer interaction interface of electronic music products optimised by this method are low, and the practical application effect is not good.

Owing the above method in the design process, not as a key to consider the visual attention allocation, leading to a lower user satisfaction and man-machine interface of electronic music products layout optimisation problem for a longer time, so this article will solve these problems as the research target, based on ERP technology of electronic music products human-computer interaction interface layout optimisation research, this method has the characteristics of high user satisfaction and short optimisation time. The overall technical route of this paper is as follows:

(1) This method uses ERP technology to design the layout optimisation architecture of the human-computer interaction interface of the entire electronic music product, including interface function module, entity modelling module, interface setting module, rendering module and virtual interaction module.

(2) with the support of optimisation architecture using the G_1 method to determine the electronic music products human-computer interface to the importance of the goal on the layout, combined with the judgment result will eventually interface layout of visual attention allocation to achieve optimal as objective function, the layout of the building based on visual attention allocation optimisation model, using particle

swarm algorithm to solve the model. The results of the layout optimisation of the human-computer interaction interface of electronic music products are obtained.

(3) Verify user satisfaction and optimisation time through simulation experiment.

2 Layout optimisation of human-computer interaction interface of electronic music products

2.1 Overall structure

The layout of the human-computer interaction interface of electronic music products based on ERP technology designed in this paper belongs to a hierarchical structure, which can optimise the extensibility of the human-computer interaction interface of electronic music products and the cycling performance of the system function modules (Brinkley et al., 2019). This structure includes interface function module, entity modelling module, interface setting module, rendering module and virtual interaction module (Wang, 2020). The overall architecture of human-computer interaction interface layout of electronic music products based on ERP technology is shown in Figure 1.

(1) *Entity modelling module*: This module uses regular grid method to realise 3D terrain simulation and design, and constructs a 3D terrain model that can conveniently complete the interactive set of electronic music products (Sun et al., 2019).

(2) *Interface setting module*: This module realises the virtual interactive information setting of electronic music products. Users can design and modify the information setting of electronic music products in a completely visual way according to their own ideas (Gao and Huang, 2019).

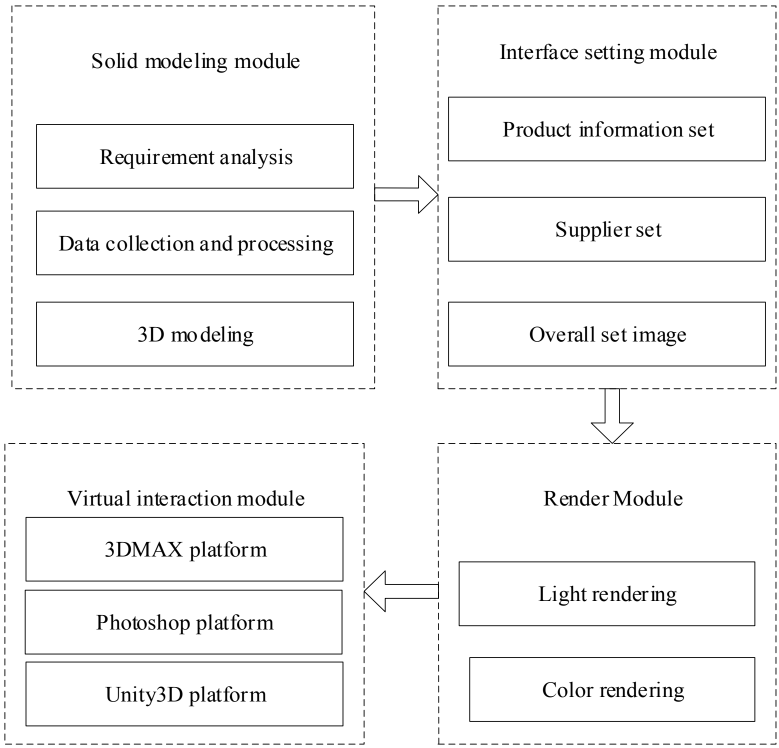
(3) *Rendering module*: This module mainly completes the effect rendering of the human-computer interaction set of the entire electronic music product through the processing of lighting, colour, atomisation, etc.

(4) *Virtual interaction module*: This module mainly provides users with the display of interactive electronic music product information (Liu and Tang, 2020).

2.1.1 Entity modelling module design

Entity modelling module is the basis of realising the interactive setting of electronic music products. Regular grid method is used to simulate and design electronic music products. The local difference algorithm is used to sample a group of finite digital elevation on the surface of electronic music product information (Liu et al., 2020), and then transform it into Digital Elevation Model (DEM) data of regular grid. The sampling accuracy of natural electronic music product information determines the accuracy of the final 3D simulation. The 3D model is used to accurately restore the data information of natural electronic music products. Manual intervention was used to calculate the accuracy of sampling points to control the accuracy and range of sampling points to avoid influencing the simulation results (Aydin et al., 2020). The DEM model is used to complete the interface layout design of electronic music products, simulate the site topography and at the same time realise the information analysis of electronic music products and the human-computer interaction layout transformation of electronic music products (Yang, 2018). The specific design process is shown in Figure 2.

Figure 1 Overall architecture of human-computer interaction interface layout of electronic music products based on ERP technology



2.1.2 Interface setting module

The interface set module realises the interface set of electronic music on the basis of the above 3D model by constructing the 3DS ERP interactive set model of electronic music (Huang, 2020). The CAD plan obtained during data collection is introduced into 3DS ERP, and the electronic music data information in the obtained plan is combined to stretch the electronic music products. For complex products, the 3DS ERP modelling method is used to split them into multiple units and synthesises them as a whole. In order to increase the authenticity of electronic music scenes, the material editor is used to add real-textures (Yu et al., 2020). In general, different objects have different textures (Wu, 2018). For example, lighting, stage, screen, etc. in electronic music set can be completed through the combination of bulletin board technology and transparent texture technology. The construction process of electronic music interactive set model is shown in Figure 3.

Figure 2 Design process

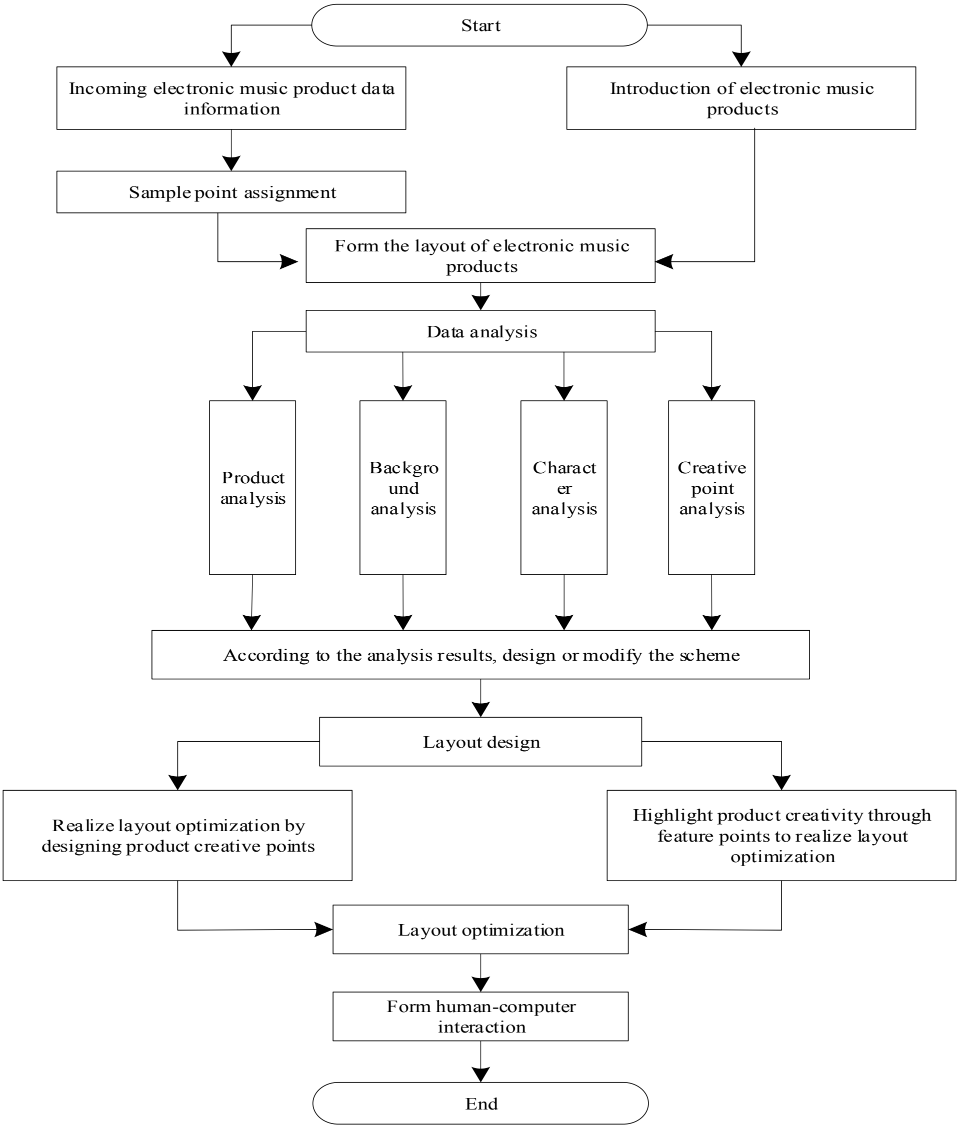
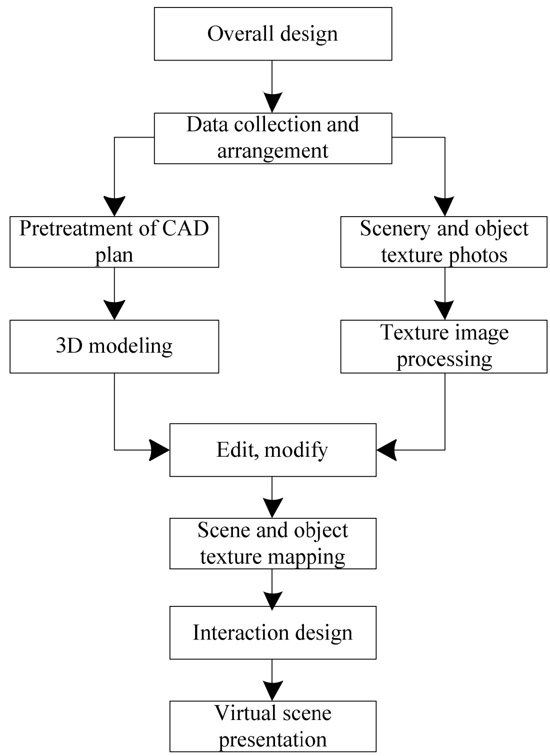


Figure 3 3DS ERP electronic music set model



2.1.3 Render module design

In order to make the human-computer interaction set of electronic music products present a good virtual effect, appropriate and good lighting performance should be provided in addition to good design, delicate model and delicate material (Qiao, 2019). Owing the reflection of the bright side, grey side, dark side and shadow of the scene and object, it mainly relies on the interaction between lights to render the whole ERP electronic music scene space to make it more real. Therefore, lighting plays a key role in the quality and value of a work (Doering et al., 2019).

The rendering module uses two kinds of lights of the 3DS ERP electronic music interactive set model to realise the lighting rendering of electronic music interactive scene.

(1) *Standard light*: Target Spot light is the main light source, which can simulate the natural solar light source and has the characteristics of fast calculation speed.

(2) *VRay lighting*: This kind of lighting has the characteristics of rich changes, large amount of import and rich adjustable parameters, which can render a more realistic scene effect (Carroll and Dahlstrom, 2021).

Use lights in the scene, must first to use the main light source Target Spot lights, namely analogue electronic light source, light intensity, reflecting light is downy, make whole space carry bright (Ma et al., 2020), can make the space environment atmosphere have to distinguish between primary and secondary levels before and after and distinction and to electronic music in different scenarios, adjust the different lights, realise the rendering of different effects, so that the whole scene effect more realistic. Rendering effect is shown in Figure 4.

Figure 4 Electronic music lighting renderings

Before rendering

After rendering

2.1.4 Virtual interaction module design

The design of virtual interaction module is mainly to realise the human-computer interaction of electronic music products.

Interactive set visualisation design, virtual interactive module of garden interactive set visualisation is mainly realised through three technology platforms. They are 3DMAX platform (3D visual modelling), Photoshop platform (UV texture processing) and Unity3D platform (interactive implementation).

(1) *3DMAX platform*: Mainly used for basic modelling of the whole scene, response endowing of material, atmosphere rendering of lighting and basic camera setting, etc.

(2) *Photoshop platform*: This platform is mainly used for editing, modifying scene material and making interface, etc.

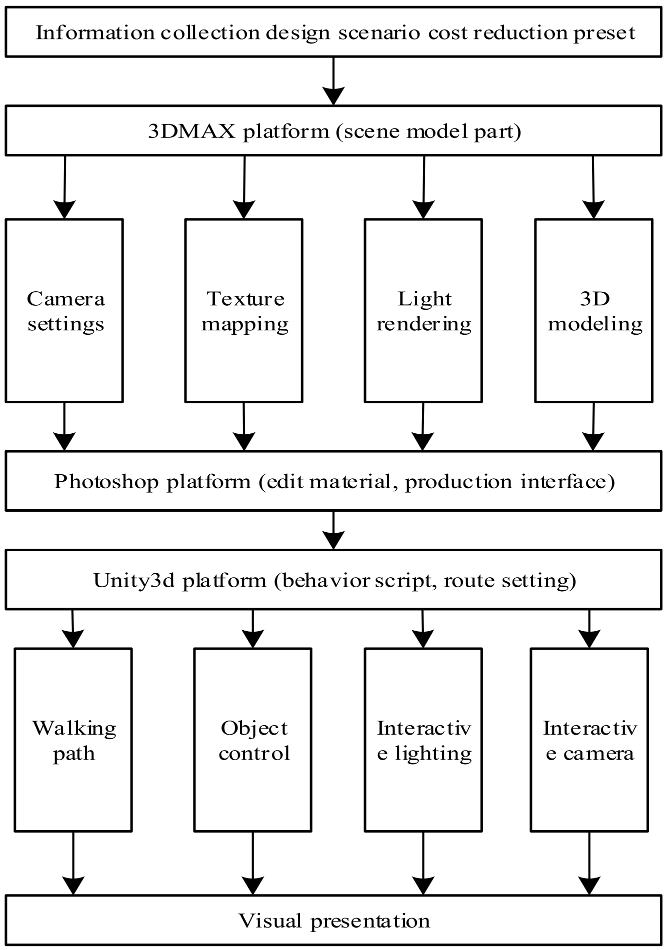
(3) *Unity3D platform*: Mainly used for behaviour script setting, route setting, interactive editing and production, etc.

Several platforms are connected with each other and support each other to form a complete technical application process to realise the visualisation of virtual electronic music interactive scenery. The specific process content is shown in Figure 5.

2.2 Interface layout optimisation model based on visual attention allocation

Supported by optimising architecture according to the layout of menus, toolbars, buttons, fields, parameters, such as, build the human-computer interaction interface layout model of electronic music products, in order to complete the transformation of engineering problems to mathematical problems using the G_1 method to determine the electronic music products man-machine interface to the importance of the goal on the layout, combination judgment result will eventually interface layout of visual attention allocation to achieve optimal as objective function, the layout of the building based on visual attention allocation optimisation model, using particle swarm algorithm to solve the model, music electronics human-computer interaction interface layout optimisation results are obtained, so the method has high user satisfaction and optimise time is short and other characteristics.

Figure 5 Visual design process of human-computer interaction set for electronic music products



According to the menu, toolbar, button, field box and other parameters in the interface layout, the human-computer interaction interface layout model $R(t)$ of electronic music products is built, so as to complete the transformation from engineering problems to mathematical problems. The G_1 method is used to judge the importance of each target on the human-computer interaction interface of electronic music products. According to the influence of different interface layout targets on the final layout results, the importance and importance of all targets are compared and the relative importance can be calculated by the following formula:

$$r_{k=\frac{w_{k-1}}{w_k}} \quad (1)$$

In the above formula, w_k represents the importance of page layout goal u_k, and the assignment of r_k is shown in Table 1.

Table 1 r_k assignment

The value of r_k	*A detailed description*
1.0	Both goals are of equal importance
1.2	Goal w_{k-1} is slightly more important than the other goal w_k
1.4	Goal w_{k-1} is significantly more important than another goal w_k
1.6	Goal w_{k-1} is strongly important in comparison to another goal w_k
1.8	Goal w_{k-1} is extremely important compared to another goal w_k

Based on the above, the weight of page layout target u_k is calculated, and the result is as follows:

$$w_i = \left(1 + \sum_{k=2}^{n}\prod_{i=k}^{n} r_i\right)^{-1} \quad (2)$$

In the above formula, $i = 1, 2, ..., n$; r_i represents the *i*-th layout target.

In this paper, based on the analysis of the importance of the goal of human-computer interaction interface layout of electronic music products, the optimisation model of human-computer interaction interface layout of electronic music products based on visual attention distribution is built with the optimal visual attention distribution as the objective function.

The model is defined as follows:

1) The visual attention level of the unit occupied by the target in the visual field of different levels is $Q = \{q_{ij}\}$, q_{ij} is the visual attention level of the unit occupied by target i in the field of vision j.

2) The visual attention level in the visual field where the centroid of the target is located is $E = \{e_{ij}\}$, e_{ij} represents the visual attention level of the centroid of target i at field j.

3) The number of units occupied by the target in the field of vision at different levels is $D = \{d_{ij}\}$, d_{ij} is the number of units occupied by the target i in the field of vision j. Where, $i = 1, 2, ..., n$, n is the number of target modules; $j = 1, 2, 3$, representing visual field *A*, *B* and *C*, respectively.

For electronic music products, the more important the HMI layout is, the target should have a certain area and be as close to the visual centre as possible. The intensity of visual attention distribution was defined as Z :

$$Z = \sum_{i=1}^{n}\sum_{j=1}^{3} \mathrm{w}_{\mathrm{i}} q_{ij} e_{ij} d_{ij} \tag{3}$$

Assuming $Y = \max Z$, the following formula exists:

$$Y = \max \sum_{i=1}^{n}\sum_{j=1}^{3} \mathrm{w}_{\mathrm{i}} q_{ij} e_{ij} d_{ij} \tag{4}$$

Among them,

$$\sum_{j=1}^{3} d_{ij} = d_i \tag{5}$$

$$\sum_{i=1}^{n}\sum_{j=1}^{3} d_{ij} = S \tag{6}$$

Formula (5) indicates that the number of units occupied by target i in the visual field at different levels is equal to the number of units occupied by target i in the visual field. Formula (5) indicates that the units occupied by all targets in visual field areas of different levels are equal to the areas of all targets in visual field. The higher the value of Z is, the more important target modules the user's visual attention is allocated.

Particle swarm optimisation is applicable to the space with unclear search scope. Each particle in the space represents a potential solution for the optimal distribution of visual attention intensity Z . Introduced the inertial weight w_{i} into the basic particle swarm optimisation algorithm, it can not only maintain the global search and optimisation ability of particle swarm, but also enhance the local search and optimisation ability of particle swarm effectively. Accessor methods of inertia weight to roughly at present: fixed weight method, the random weighting method and linear decreasing weight method and so on, diminishing the linear weighting method is more flexible than other two methods reflect the advantages of the inertia weight varies with the number of iterations, so this article will be applied to the optimisation process of Particle Swarm Optimisation (PSO), make the algorithm has higher speed and precision in a variety of advantages.

Particle swarm optimisation algorithm is used to solve the layout optimisation model of human-computer interaction interface of electronic music products, and the parameters such as menu, toolbar, button and field box are optimised. The specific results are as follows:

$$R'(t) = Y - w_{\max} - \frac{w_{\max} - w_{\min}}{T_{\max}} \times t \tag{7}$$

In the above formula, $T_{\max}$ and t , respectively represent the maximum number of iterations and the current number of iterations.

3 Simulation analysis

3.1 Experimental scheme design

In order to test the layout optimisation of human-computer interaction interface of electronic music products based on ERP technology designed in this paper, simulation experiment is required. The specific experiment scheme is as follows:

(1) *Experimental environment*: The design of the experimental environment is shown in Table 2.

(2) *Experimental data*: Take a certain type of electronic music products as the research object, test data and product use data as the experimental sample data, the collected data are cleaned, de duplicated and filled and the processed experimental data as the experimental sample data, so as to improve the accuracy of simulation experiment.

(3) *Experimental evaluation index*: The Kang et al. (2020) method, Han and Zhao (2018) method and the method in this paper were taken as the experimental method. Taking user satisfaction and optimisation time as evaluation indexes, the higher the user satisfaction is, the more satisfied the user is with the human-computer interaction interface layout of electronic music products and the better the application effect is. The shorter the optimisation time is, the higher the optimisation efficiency is.

Table 2 Experimental environment design

Runtime environment	*Configuration*	*Parameter*
Hardware environment	CPU	Intel(R)Core(TM)i5-9400
	Frequency	2.90 GHz
	RAM	16.0 GB
Software environment	Operating system	Windows 10
	Version	18362.1082 pro
	Digits	64 bit
	Analogue software language	APDL
	Simulation software	Matlab 7.0

3.2 Survey and statistics of user results

In order to verify the application performance of the system in this paper, the overall feedback of 1000 users after using the system was counted. The results are shown in Table 3.

By analysing the statistical results of user feedback in Table 3, it can be seen that most users are very satisfied with the 9 evaluation indexes of the system in this paper, such as interface clarity, scene authenticity and scene rendering, and only less than 0.3% of users are dissatisfied with the system. The experimental results show that the system in this paper meets the requirements of most users, which indirectly indicates that the system in this paper has good performance.

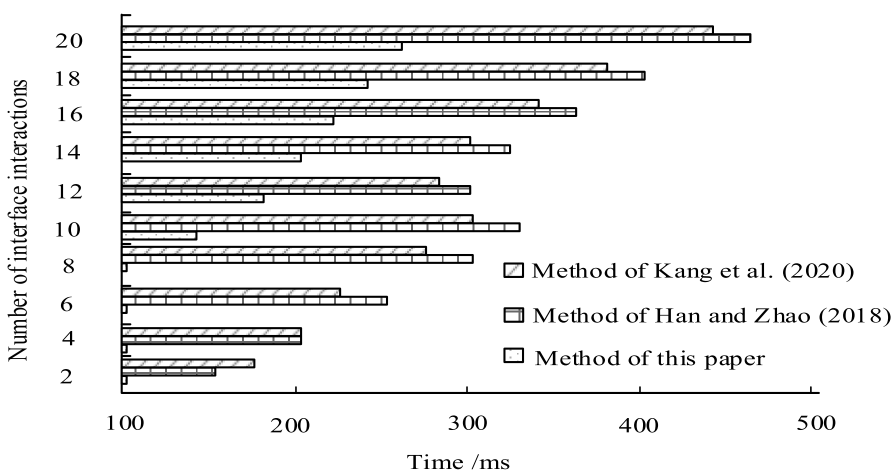
Table 3 User survey statistics

Evaluation index	*Very satisfied/%*	*Good/%*	*General/%*	*Not satisfied with the/%*
System rationality	98.2	0.8	0.7	0.3
Interface clarity	98.7	0.7	0.4	0.2
Scene Reality	98.8	0.5	0.4	0.3
Operating fluency	97.7	1.1	0.9	0.3
Colour fullness	98.5	0.9	0.4	0.2
User Satisfaction	99.1	0.4	0.3	0.2
Scene renderability	98.2	0.8	0.7	0.3
Easy to operate	98.6	0.7	0.5	0.2

3.3 Optimisation time survey statistics

The time required to optimise the human-computer interaction interface of electronic music products was counted using the Kang et al. (2020) method and Han and Zhao (2018) method as well as the method in this paper. The statistical results are shown in Figure 6.

Figure 6 Comparison of optimisation time of different methods



As can be seen from the experimental results in Figure 6, the time required to optimise the human-computer interaction interface of electronic music products by using the method in this paper is less than 300 ms, while the time required to optimise the human-computer interaction interface of electronic music products by using the Kang et al. (2020) method and the Han and Zhao (2018) method is more than 300 ms. The comparison results effectively verify that the method presented in this paper can achieve high-quality optimisation of the human-computer interaction interface of electronic music products in a relatively short period of time and has high real-time performance.

4 Conclusion

This paper designs the layout optimisation method of human-computer interaction interface of electronic music products based on ERP technology. By using the way of collocation of words and pictures, it introduces in detail the technical realisation of this method in the interaction of ERP electronic music and the operation process in the process of use, and combines theory with practical operation. Using virtual reality technology and 3D technology a good present a complete ERP electronic music interactive landscape, make the ERP electronic music had no vitality in the construction, character and landscape, can be presented to the user in a vivid and flexible and improve the whole page layout fun and interactivity, explain to the user system can intelligent ERP all landscape in the electronic music, to a great extent, increase the user's interest in watching and real feelings.

References

Aydin, Y., Tokatli, O., Patoglu, V. and Basdogan, C. (2020) 'A computational multicriteria optimization approach to controller design for physical human-robot interaction', *IEEE Transactions on Robotics*, pp.1–14.

Brinkley, J., Posadas, B. Sherman, I., Daily, S.B. and Gilbert, J.E. (2019) 'An open road evaluation of a self-driving vehicle human-machine interface designed for visually impaired users', *International Journal of Human-Computer Interaction*, Vol. 35, No. 11, pp.1018–1032.

Carroll, M. and Dahlstrom, N. (2021) 'Human computer interaction on the modern flight deck', *International Journal of Human-Computer Interaction*, Vol. 37, No. 7, pp.585–587.

Doering, M., Glas, D.F. and Ishiguro, H. (2019) 'Modeling interaction structure for robot imitation learning of human social behavior', IEEE *Transactions on Human-Machine Systems*, Vol. 19, No. 1, pp.1–13.

Gao, H. and Huang, W.Q. (2019) 'Layout optimization design of automobile human computer interaction information interface based on visual cognition theory', *Western Leather*, Vol. 41, No. 21, pp.87–89.

Han, D. and Zhao, S.B. (2018) 'Layout optimization of human computer interaction mobile phone interface based on mathematical statistics', *Mathematics Learning and Research*, Vol. 15, No. 4, pp.144–149.

Huang, D.H. (2020) 'Research on electronic product design based on human-computer interaction', *Modern Information Technology*, Vol. 4, No. 17, pp.52–54.

Kang, H., Yang, S.X., Deng, S.W. and Wang, B. (2020) 'Multi objective optimization design of product operation interface element layout', *Packaging Engineering*, Vol. 41, No. 8, pp.163–167,186.

Liu, H.R. (2019) 'Design of color enhancement system for planar visual image of human-computer interactive interface', *Modern Electronics Technique*, Vol. 42, No. 8, pp.85–89.

Liu, X.D., Chen, Z., Chen, J., Wang, Z.G. and Chen, D. (2020) 'Research on human machine interface design for the tobacco silk production line', *Electrical Automation*, Vol. 42, No. 2, pp.116–118.

Liu, Z.H. and Tang, Y. (2020) 'The design of human-computer interaction interface in vehicle under the background of artificial intelligence', *Industrial Engineering Design*, Vol. 2, No. 2, pp.148–154.

Ma, C.M, Zhao, D.H. and Xin, H. (2020) 'Human-machine interaction interface design of intelligent equipment based on user experience', *Computer Integrated Manufacturing Systems*, Vol. 26, No. 10, pp.52–62.

Qiao, X.J. (2019) 'The research on human-computer interaction interface based on user experience in government affairs system', *Modern Industrial Economy and Information Technology*, Vol. 9, No. 10, pp.69–71.

Shank, D.B., Wright, D., Lulham, R. and Thurgood, C. (2020) 'Knowledge, perceived benefits, adoption, and use of smart home products', *International Journal of Human-Computer Interaction*, Vol. 22, No. 1, pp.1–16.

Sun, B.W., Yang, J.M. and Sun, Y.B. (2019) 'Research on interface hierarchy design for human vehicle interaction', *Journal of Machine Design*, Vol. 36, No. 2, pp.125–129.

Turchet, L. and Barthet, M. (2019) 'Co-design of musical haptic wearables for electronic music performer's communication', *IEEE Transactions on Human-Machine Systems*, Vol. 49, No. 2, pp.183–193.

Wang, S.L. (2020) 'Simulation of visual saliency evaluation method for multimedia human-computer interaction interface', *Computer Simulation*, Vol. 37, No. 3, pp.161–164.

Wu, C.Y. (2018) 'Sound design and implementation of the interactive electronic music', *Microcomputer Applications*, Vol. 34, No. 11, pp.80–82, 87.

Yang, Y.H. (2018) 'On the emotional design of human computer interactive graphical interface', *Art and Technology*, Vol. 31, No. 5, pp.180–187.

Yu, S.Y., Liang ,Y.X., Tan, D.N., Xu, W.L., Gong, C.L. and Zhu, C.X. (2020) 'Research on consistency in product human machine interface design', *Science and Technology Information*, Vol. 18, No. 4, pp.13–15, 18.