Research Article

Human-Machine Interface Visual Communication Design Model of Electronic Equipment Using Machine Vision Technology

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Abstract

Electronic equipment has high precision, high reliability, high stability, and high security, as well as the ability to adapt to a variety of challenging environments. With the rapid advancement of mechanization, automation, and electronization, the impact of human factors in production is growing, and designers are increasingly concerned about the problem of man-machine coordination. It is critical to have a man-machine interface that is suitable for operators’ thinking and behavior and has a guiding function. The accuracy and timeliness of equipment control are linked to the human-computer interaction interface. The visual characteristics of human cone cells are used to divide the neural visual perception intensity grades. With the visual communication index as the optimization goal, a mathematical model of human-computer interaction interface optimization is established and solved using a genetic algorithm. This method is used to optimize the design of a human-computer interaction interface, and the results show that the visual communication index of the optimized human-computer interaction interface has improved significantly.

1. Introduction

In recent years, electronic equipment has been widely used in public life, and its interface design has become an indispensable part of art design. In particular, various software applications in electronic equipment are no longer the artistic appearance and single presentation of information. Comfortable human-computer interaction and good user experience have gradually become the focus of designers and users [1]. To learn more about the interface design of electronic equipment in the classroom, visual communication design focuses on conveying information, uses vision as a means of communication and expression, visually designs and processes information using graphics, color, material, and appearance, and accurately and effectively transmits information to meet the needs of people’s information exchange. For designers, manufacturers, and audiences alike, accurate communication has become a source of frustration [2]. This necessitates conducting scientific logical analysis, data collection, and calculation for users, striving to display the audience’s biased perception data when receiving visual information and product experience in the most rational way, and displaying the user’s demands and design deficiencies through data [3]. The development of man-machine interface design in China is still in the primary stage compared with developed countries, but in recent years, with the development of the Internet, people have higher and higher requirements for visual aesthetics of man-machine interface design, pay more and more attention to the perfect combination of art and technology of man-machine interface, and pursue personalized visual enjoyment [4]. However, in the early software design, designers focused on the function design of the software and ignored the interface design. They often started the interface design at the last stage of the design, which is difficult to achieve the ideal user experience effect.

Most of the information that people get about the running state of electronic equipment comes from the visual expression of various elements in the human-computer interface. Visual cognition is to use vision to distinguish,
understand, and judge what you see. In this process, in addition to the visually acquired information, it also needs the human brain to process the acquired information many times to get the overall situation of things [5]. Man-machine interface is an important component of man-machine interaction technology, which displays various visual information to provide the basis for users' judgment. Electronic equipment’s man-machine interface has a complex structure, multidimensional expression, and massive information [6]. Visual communication design is more than just the aesthetic enhancement of visual information; it also allows people to communicate and perceive the essence of design accurately through information, allowing the design to become more efficient. The user interface of an electronic device is a window through which users interact with systems and applications, and it must be designed appropriately based on the physical characteristics of devices and the characteristics of system applications [7]. This “reasonable” design begins with multifaceted and multidisciplinary considerations that meet the needs of human vision and ergonomics and continues with humanized, detail-oriented, and simple-to-operate interface design, with User Experience Design (UED) and product icon design being the two most important aspects. We can only create excellent works if the two are perfectly integrated [8]. This paper proposes an interface design method and criteria for designers based on research and analysis of visual communication design of electronic equipment’s human-computer interface.

Man-machine interface design has gone from satisfying users' functional and aesthetic needs to gradually paying attention to experiences that are more humanized and more easily accepted by users [9, 10]. Man-machine interface design is a comprehensive design category combining art and technology. Visual designers need to cooperate with interactive designers and follow the design principles of human-computer interface: simplicity principle, consistency principle, rationalization principle of layout, etc., under the premise of continuous improvement of technology, to show their works to users more artistically [11]. As visual designers, our task is to determine the audience, understand the cognitive process of users from the perspective of cognitive psychology, and explore how to better and more effectively transmit information to users [12]. In order to further explore the problem of interface design in electronic equipment, this paper proposes a user experience-oriented design method of human-computer interface. By analyzing UED, a mapping model between interface provider and interface receiver is proposed. The interface is divided into explicit elements and implicit elements, and the explicit design model of implicit elements of the interface is established. Aiming at the new software design, through the transfer and transformation of knowledge between requirement analysis, development design, and design test, a user experience-oriented interface design process model is constructed. Let users participate in the whole process of design, and use the method of design anthropology to conduct user research and demand analysis. Through iterative design, the prototype design, test evaluation, and development design are completed, the system prototype is established, the usability test evaluation is completed, and the theoretical system of user experience-oriented interface design is verified.

2. Related Work
The user-centered and incremental design method is used in literature [13, 14], and the main line for designing the mobile phone interface prototype for illiterate use is the user’s use situation and experience. According to the literature [15], user-centered and people-oriented design has gotten a lot of attention from designers and users. User research is the first and most important link in software interface design, according to literature [16]. Understanding the actual needs of users is the foundation of good service. Typically, software designers must research users' psychological and behavioral characteristics in the context of their actual work and living environments, as well as deeply tap into users' psychological needs. The management conference system was used as an example in reference [17], which proposed a user-centered pen-based user interface design method based on scene tree. According to literature [18], it can provide reference and thinking for the design of innovative products based on the user’s cognition of product structure, form, and color, ensuring product development success. Web interface design, according to literature [19], is multifactorial: it incorporates various knowledge of technology, art, and psychology. Although technology is the foundation for presenting art, there are differences in how it is used. A good web interface design is both simple and beautiful, and it is the most important factor in eliciting emotional responses from users. According to the literature [20], the actual development and design of software is divided into two parts: interface design and function design. Reference [21] discussed the software interface design process and proposed a user-oriented software interface design method. UED is a subset of the field of experience design, according to literature [17], and its research influences users' feelings about using products or services, as well as the interaction between users and products, including how users understand, learn, and use products. According to literature [22], when designing portal websites, we should make sure that the visual clarity of colors is strong and that they are appropriately matched. All information elements on the page must be layered at the same time, and sections at all levels must be interconnected. Make the page level clear, focused, neat, and generous, and ensure that the main content is easily identifiable. Literature [23] starts with usability and works to improve the product experience through attribute measurement research. Literature [24] suggested that user cognition and emotional experience should be considered in design, based on emotional design and design psychology. User experience, according to literature [25], consists of five layers: performance layer, framework layer, structure layer, scope layer, and strategy layer. Literature [16] believes that the user experience evaluation method should integrate cognitive and emotional factors and take the emotional evaluation as a part of the comprehensive evaluation method of user experience. Literature [26]
proposed four evaluation indicators to quantify user experience: brand, usability, functionality, and content. On the basis of previous studies, based on the research methods of ergonomics and visual perception, taking the information interaction of electronic equipment in specific production as the design starting point, this paper analyzes the human-computer characteristics of the display and controller of vector controller. Also covered is the significance of design principles that electronic equipment should adhere to when creating a man-machine interface. On this foundation, specific and effective visual communication design principles for human-computer interfaces are proposed, such as functional area layout, character, graphic, symbol design, color coding, hearing, touch, and other design principles. The goal of comfortable operation, simple identification, and high accuracy is achieved through the design based on visual perception.

3. Methodology

3.1. Methods and Criteria of Electronic Man-Machine Interface Design for Equipment. The interface exists to make users interact with designers, users and software applications, users, and other users. It can not only bring us together but also separate us, so as to complete the value of products and serve the public. The visual expression of man-machine interface design is mostly related to the content. Different styles and features between electronic device interfaces are shown in different visual forms [27]. Form exists in everything, and visual designers can learn from nature and stimulate creative inspiration through the discovery and exploration of various forms of nature. Then, according to the formal law of beauty, we create the man-machine interface design works with certain aesthetic feeling.

The display and control system of electronic equipment is typically a coordinated whole, with the display serving as both feedback and transmission of controller operation information. We should do our best to reduce the complexity of operation and display in the layout design of the display and controller, improve work efficiency, and reduce the time it takes for users to learn and use the equipment. As a result, when designing a display and controller, the goal is to make man-machine interaction simple, quick, and error-free. Aesthetic schools have a significant impact on the visual form of human-computer interface design; at the moment, human-computer interface design tends to be minimalist, and a calm layout gives people a neat visual feeling, which is linked to minimalism’s influence [28]. Of course, not every page is appropriate for a minimalist design. At the same time, other aesthetic schools, such as internationalism, have a significant impact on the design of human-computer interfaces. What style to use as an interface form is largely determined by the content.

The key point of user experience-oriented interface design is to consider the interaction quality and experience feeling between interface provider and interface receiver. Its purpose is to closely focus on users in the process of interface design, to have users’ participation in the process of system design and testing, to get users’ feedback information in a timely manner, and to continuously improve the design according to users’ needs and feedback information until the users’ experience needs are met. The mapping model between the interface provider and the interface receiver is shown in the model of Figure 1.

The function and effect of interface design can be predicted and measured, that is, the use effect can only be known through testing, so they cannot be utilitarian. Excellent interface design can not only arouse our connection with the world but also make us get twice the result with half the effort. There are four basic principles to guide the design of electronic equipment. (1) Fully consider the logical relationship between display and control to improve work efficiency and reduce errors. (2) Fully consider the actual working environment and use requirements, as well as the movement habits formed by people’s physiological characteristics, and arrange the monitors and controllers reasonably. (3) According to the composition of display and control function groups, considering the visual and use functions, the efficiency and accuracy of identification can be improved. (4) Considering the aesthetics of the overall layout, the design of electronic equipment should not only have its substantial functionality but also have good aesthetics, which fits the user’s life and improves the work efficiency.

User choice and use are the success of interface design. Therefore, the interface exists in order to create as many user-friendly environments as possible, taking into account as many users of different ages, classes, nationalities, and cultures as possible. Through the display of information, users can judge their next operation and operate the equipment through the control system. The channels through which people can obtain information from the outside world mainly include the sensory organs such as eyes, ears, and nose. Generally, visual information transmission is chosen. However, in order to ensure the information flow of man-machine system smoothly through man-machine interface, other ways will be chosen as an aid to make up for the defects of vision when receiving information, which is also the requirement of man-machine interface design.

Input information, information cognitive processing, decision-making, and behavioral response are the four parts of the visual information communication process. The information in the man-machine interface should be useful to the human senses, and the human body should be able to form a short memory impression based on the information received. The input information urges the visual elements to have certain consciousness and emotional states after many times of processing. Users can retrieve these states based on their own knowledge and experience and then make sound judgments and decisions. According to the judgment made, users actually respond to the information given by the man-machine interface of electronic equipment. The visual information flow is shown in Figure 2.

Color is the most sensitive visual perception information in the human eye, and the color design of a man-machine interface directly influences its use effect. The more colors in the design of a man-machine interface, the better. The
The goal of color design for man-machine interfaces is to improve the visual impact of users. The use of color in man-machine interfaces can help users improve their ability to perceive information and increase task execution efficiency. It is critical for users to have a firsthand experience with the interface, which is often overlooked by designers. The design of the interface should provide direction and guidance to guide users to enter the situation quickly and play a good guiding role in order to make users more familiar with application systems and use them quickly. The ability of users to reliably receive and accurately feedback information transmitted by electronic devices has a direct impact on their working efficiency and operating comfort.

Through regular systematic combing, describe causality, and give tips before every step of operation, so that users can feel that every step of operation after that is under his control. Then such a comfortable interface design is bound to be reused and continuously used by first-time users, and they will be passed down from mouth to mouth, so that users can introduce it to people around them like discovering the New World and provide high-quality services for...
their own life and study through use, so this is the importance of users' first experience, which directly affects the later communication function and effect.

In order to make the picture have a clear visual browsing order, the strong visual level becomes the first factor. In the past, the color design method of electronic equipment man-machine interface using graphic element fire control system and new energy storage converter, the designed man-machine interface of electronic equipment has a short attention time, and users cannot perform tasks efficiently. However, using visual communication technology can design the color of man-machine interface according to the transmission of human visual information. In the process of concrete implementation of design, color matching is particularly important. The contrast between icon color and overall color and the harmony of final effect should be considered to meet the needs of users' aesthetics and visual comfort.

3.2. Interface Visual Communication Design Model. There are many problems in the actual R & D and design of electronic equipment. The above principles can be used as a reference for product design. This paper puts forward the specific design method of man-machine interface of vector controller. The layout design of man-machine interface for display and control system aims to improve the use efficiency, safety factor, and comfort of electronic equipment.

Color can more or less affect a person's emotion, just as people's visual, auditory, tactile, olfactory, and other experiences will directly affect people's psychological and physiological reactions to varying degrees. Different hues, warm, and cold contrast can make users have different psychological feelings. Second, things with freshness can attract people's attention. Therefore, color personalized design is an important link of interface design. The purpose is to use color transformation to mobilize and adjust users' psychological needs, so that users can always maintain a freshness to software products. The color design of man-machine interface of electronic equipment is related to the attention and visibility of the interface. The design of interface color needs the designer to make the design according to different electronic equipment. The hue and hue can be changed according to the needs of users, so that they can choose according to their favorite personalized interface color to improve user satisfaction. At the same time, using personalized settings in electronic devices can also improve the charm and activity of software and meet the multidirectional needs of users. Multiresolution and multiscale algorithm can enhance the display effect of man-machine interface images of electronic equipment. The truncation and stretching formula is

$$T_{out} = \begin{cases} 0, & T_{in} < T_{low}, \\ T_{in} - T_{low}, & T_{low} \leq T_{in} \leq T_{high}, \\ e_{max}, & T_{in} > T_{high}, \end{cases}$$

where $T_{in}$ and $T_{out}$ are the input and output values of the interface color channel, respectively. $e_{max}$ represents the maximum dynamic range value of the interface image output. $T_{high}$ and $T_{low}$, respectively, represent the upper and lower intercept points of the histogram, and their expressions are

$$\begin{align*}
T_{high} &= \alpha + h\beta, \\
T_{low} &= \alpha - h\beta,
\end{align*}$$

where $\alpha$ and $\beta$ represent the mean and standard deviation of color channels of human-computer interface images, respectively. Moreover, the value of constant $h$ in the formula seriously affects the enhancement effect of interface image color. The higher the $h$ value, the better the interface color balance, the less brightness information there is, and the blurrier the interface image becomes. The image enhancement resolution parameter is what it is called. People are always most relaxed and happy when their behavior meets their expectations, and they have a good relationship with people or things who meet their expectations. As a result, the design of icons should, of course, be consistent with their functions. Users should be able to predict what this application will do as long as they see this interface element. Characters or symbols used to clearly indicate the functions, uses, and ranges of displays, controllers, and other connectors are known as text and graphic symbols. Users can operate the equipment accurately and quickly thanks to the design of these symbols, avoiding misoperation.

The multiresolution and multiscale Retinex algorithm is used to enhance the color image enhancement algorithm of electronic equipment man-machine interface. The calculation process is as follows:

$$r(x, y) = \sum_q \sum_w \omega_{q,w} \left\{ Q \cdot S(x, y) - W \cdot F(x, y) \right\},$$

where $r(x, y)$ is the enhanced color image of the human-machine interface. $S(x, y)$ is the original color image of the man-machine interface. The function $F(x, y)$ is the center wrap function. $Q$ is the number of multi-resolution; $W$ is the number of wrapping functions; the weight $\omega$ is

$$\omega_{q,w} = \frac{1}{(W \cdot Q)}.$$
man-machine interfaces. Effective graphic expression can save words and make people more clear at a glance, and images can express and supplement content. Some can also serve as a source of information or a comprehensive visual display. It can also play a role in page layout by adjusting the layout. It is also crucial to know if the arrangement of display and control devices can be expressed clearly and accurately. There are several methods for laying out the panel’s functional areas, including the separation method, wireframe method, and facet method.

Moderate can reflect the clustering degree of nodes according to Europe in the whole space, specifically as follows:

$$F(N) = \frac{1}{N} \sum_{k=1}^{n} f(O_k).$$  \(5\)

\(N\) refers to the number of nodes in the sample space. The value of \(F(N)\) is between \([0,1]\), and in the process of clustering, the degree of parallelism obtained will continue to increase to obtain the maximum value.

A certain visual perception element is arranged on a certain position of the human-computer interaction interface. If its visual perception intensity index \(r_j\) is larger, the area where it is located is closer to the core area of the human-computer interaction interface. The mathematical model of human-computer interaction interface optimization design based on visual perception is

$$Z = \max \sum_{i=1}^{n} \sum_{j=1}^{m} d_i x_i q_{ij}.$$  \(6\)

Satisfied:

$$\sum_{i=1}^{n} q_{ij} = q_p,$$  \(7\)

$$\sum_{j=1}^{m} q_{ij} = s_j,$$  \(8\)

$$\sum_{j=1}^{m} q_j = \sum_{i=1}^{n} s_i.$$  \(9\)

UED’s main goal is to create products that are tailored to the user’s preferences, based on the usability principle and incorporating vision, layout, interaction, and action design techniques. A good UED can lower development costs, improve customer satisfaction and loyalty, and boost sales.

In order for UED to be carried out in a natural, efficient, consistent, and friendly manner, it is necessary to effectively acquire the user’s experience requirements and establish a correct user model. Users’ thinking modes and operation habits should be reflected in the device layout design on the panel. The display and control devices can be organized reasonably based on their functions, operation sequence, importance, frequency of use, and other factors, after weighing the importance of each group of devices to the equipment. For an electronic device, the front panel is the primary display and operation interface. Then, on the panel, you can put some devices and connectors that are not used or used frequently.

4. Results Analysis and Discussion

Interface design is by no means a simple typesetting and the splicing of graphics and images. At the same time, we should not draw a clear line with all these disciplines, such as visual communication, layout, copywriting, and information architecture. They can all be dabbled and studied. A comprehensive understanding of each discipline can promote designers to better design and make them grow rapidly. This method’s application effect is simulated and analyzed in practice. The method is applied to the color design of the human-machine interface of electronic equipment, and the color design quality of the human-machine interface of electronic equipment is assessed. The results of the color design method of human-machine interface using primitive fire control system and the color design method of human-machine interface using new energy storage converter are used as experimental reference in order to highlight the method’s performance advantages.

In order to enhance the full understanding and analysis of the relationship between user perception and product appearance characteristics, taking automobile products as an example, the “7C” rule is adopted to collect and analyze the data of skewness perception, and the positive iterative design is carried out in time. The users used in this paper are 800 users surveyed and analyzed. For example, the semantic difference value of these users on the product appearance features indicates the membership degree of cognitive elements, which is characterized by symbolic sets. Corresponding to 10 symbolic measurement levels, through symbolization and the most suitable region method, the clustering results of both can be successfully obtained. The specific results are shown in Figures 3 and 4.

Figure 3 shows the clustering effect of users’ perception of car body. Figure 4 shows the perceived clustering effect of users on front, line, and so on based on cognition. From the analysis, it can be found through the most suitable area method that compared with exquisite perception, car body has a more prominent influence on motion perception, instrument has a stronger influence on exquisite perception, and seat has a greater influence on motion perception.

Through experiments, we found that the color design of electronic equipment’s man-machine interface, and the gaze time of test objects on login interfaces designed by different methods is quite different. Figure 5 is the curve of gaze duration of login interface.

It can be seen that the gaze duration curve of the login interface designed by this method is at the top, which shows that the test object pays great attention to the login interface designed by this method, and the color visual effect of the interface is good. Using the primitive fire control system to design the login interface, the staring time is in the middle, and the test object pays less attention to the interface. The interface designed by the new energy storage converter has
the shortest gaze time, which shows that the color visual
effect of the login interface is poor, and the test object cannot
pay attention to the interface for a long time.

In order to improve the amenity of the man-machine
interface, the design of the electronic man-machine interface
should have as much color saturation as possible while meet-
ing the functional requirements. It is critical to design the
man-machine interface of electronic equipment in such a
way that the color of the man-machine interface is reason-
ably matched and the appropriate light signal color is
selected. As a result, in order to meet the needs of man-
machine interface use, it is necessary to examine the photo-
electric signal color matching of man-machine interface for
various electronic equipment. The ability of the light signal
to be clearly transmitted and accurately expressed is critical
in the design of a man-machine interface for the equipment
and users’ working environment. Light signal characteristics,
on the other hand, are rarely considered by designers. Differ-
ett visual information can be expressed using different light
signal characteristics. Let us do the experiment again.

Figure 6 shows the curve of the gaze duration of the main
program interface of the test object.

By analyzing the three curves in Figure 6, we can see that
the gaze duration curve of the main program interface of the
electronic device designed by this method is at the top. The
main program interface designed by the new energy storage
converter has the shortest gaze duration, and the gaze dura-
tion of different test objects on the main program interface is
quite different, which shows that the interface has poor abil-
ity to attract the attention of test objects and poor color
visual significance of the interface. Important parts of an
instrument should be prominently indicated by color con-
trast to help quickly locate display or control components;
however, there should be no more than five such points.
The choice of color scheme should be combined with the
decision of lighting type. When arranging the display and
controller on the panel, we should choose the appropriate
hue, saturation, and contrast to arrange the functional areas
in different areas. In order to test the superiority of this
design, an experimental comparison is made between this
man-machine interface design and the original man-
machine interface design, and the graph shown in Figure 7
is obtained.

It is clear that this man-machine interface design is supe-
rior to the original man-machine interface design, demon-
strating the design’s feasibility. Man-machine interfaces
necessitate man-machine cooperation, i.e., coordination of
the relationship between the display, controller, sensory
organ, and motor organ, which necessitates cognition and
matching of the corresponding machine-operation relation-
ship. Because of the benefits of color in operating control
panels, equipment surface treatment, and coding, the color design of the man-machine interface is an important part of ensuring the system’s efficiency. Colors for panel surfaces, light signals, and overall equipment color coding are all considered when choosing and designing vector controller colors. For the test, we chose 500 users and rated the user experience of the human-computer interface before and after optimization. Figure 8 depicts the graph.

The acquisition and analysis of user bias perception involve a wide range of knowledge fields, but the whole process is complicated, and user perception is symbolic and uncertain. Excellent interface design is the embodiment of the designer’s solemn, persuasive, and interesting interaction with users by clarifying, simplifying, clarifying, decorating, and endowing them with value and significance, so interface design is worthy of further and more comprehensive study. In this section, on the basis of analyzing the characteristics of users’ skewness perception involved in visual communication, the correlation model between product appearance features and users’ skewness perception elements is established. Taking cognitive behavior as the standard, and through feature matching, users are analyzed in detail from two perspectives of similarity and cognition.

5. Conclusions

Interface design is a never-ending cycle of iteration and revision. Similarly, user experience is fluid, and different users have different experiences in different environments. Human-centered interface design will bring new design ideas and methods to product design by shifting the focus of design to people’s attention. In this paper, a visual communication-based design method for electronic equipment human-computer interfaces is proposed to meet the design requirements of electronic equipment human-computer interfaces that require high attention. First, understand the information conveyed by the man-machine interface; then, remember, understand, and judge the information, and make effective decisions and appropriate actions based on your own judgment results, according to the cognitive process of visual information in visual communication. Images are the information conveyed by the electronic man-machine interface of equipment, and improving the display effect of images can help to improve the interface’s attention. The shape characteristics of products and related information of users’ cognition are described in detail using iterative symbolization, and the nonlinear relationship between them is clarified, allowing for full application to product design. Under the guidance of design principles, the man-machine interface design of electronic equipment products. In addition, this method has a positive effect in practice.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

All the authors do not have any possible conflicts of interest.
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