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Visual Design of Computer Human-Computer Interaction Interface Based on Wireless Network

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The design of human-computer interaction interfaces has always been a hot topic in the field of computer science, with the main focuses being on implementation techniques, development tools, and development methods. Due to the interdisciplinary nature of human-computer interaction, it is necessary to discuss the visual design of interfaces. This study explored the visual design of computer human-computer interaction interfaces based on wireless networks, explored the constraints and visual design elements in human-computer interface design, analyzed the constraints of human-computer interaction interface design, and discussed the visual design elements such as text, image, color, etc. in human-computer interface design. The visual design standard of human-machine interfaces under a wireless network was proposed, and the color image correction and enhancement (ICE) algorithm for visual design of interfaces based on a wireless network was built. The experimental results show that the proposed color ICE system can improve the clarity of image colors. Also, when compared with the other systems used in the experiments, the color ICE based on wireless network interactive interface visual design has the shortest time consumption and highest processing efficiency for enhancing human-machine interface visual design. This proves that color ICE can improve the clarity of image colors, and color ICE based on wireless network interactive interface visual design has the shortest time consumption and highest processing efficiency for enhancing human-machine interface visual design.

Keywords: human-computer interaction, interactive interface design, visual design, computer technology, wireless network

1. INTRODUCTION

In terms of practical application, computers, humans, machines, and the environment are interconnected and form an organic whole, enabling all of its components to achieve appropriate connectivity and coordination [1–2]. The interaction between humans and machines is carried out through the user interface. Because research recognizes the strong subjective effects of visual design, it is important to study the common characteristics of computer human-computer interaction in order to comprehensively improve the visual design of computer human-computer interfaces.

The human-computer interaction interface is a medium or means of communication between humans and computers. It is a platform for bidirectional information exchange of various symbols and behaviors between humans and computers, which can improve the user's work efficiency. Xu proposed an extended artificial intelligence conceptual model from the perspective of human-computer interaction, emphasizing that the development of artificial intelligence solutions requires comprehensive consideration and ethical design, and fully considered technology that reflects human intelligence and

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human factors or ergonomic design [3]. Shilton described the history of human-computer interaction interfaces, discussing criticism of design and human-computer interaction research from relevant disciplines [4]. Diederich's research has found that in recent years, many studies have focused on human-computer interaction, which helps to understand session proxy technology. However, the current lack of a structured overview of this study hinders the systematic identification of research gaps and knowledge [5]. Sofia Seinfeld further proposed a research agenda for these concepts, which can guide the human-computer interaction community to understand from a broader perspective how users represent perception and interaction through interactive interfaces [6]. Wang introduced a new format for reporting comparative research in the field of human-computer interaction, which intuitively explained design decisions and key insights by tightly integrating text and images [7]. Kosch discussed the impact of future evaluations of artificial intelligence-based user interfaces and new technologies. It is believed that the system description can trigger a placebo effect through user expectations biased towards user centered research results [8]. All the aforementioned studies have discussed the design and analysis of human-computer interaction interfaces, but they have not addressed the visual design of human-computer interaction interfaces, and the utilization of wireless networks has not been elaborated.

When designing human-machine interfaces, it is necessary to fully consider the actual needs of users. Applying aesthetic standards to human-machine interface design can improve the visual appeal of the interface and enhance the user experience. Kahng introduced the generative adversarial network laboratory, which is the first interactive visualization tool designed specifically for non-expert learning and experimentation to generate adversarial networks [9]. Leung proposed that highlight technology is an important technology in diverse visual communication. The use and operation of any visual effect can highlight the spatial sense of the design [10]. Li believed that visual education is an emerging educational method, and designed and applied a visual teaching method for university courses based on human-computer interaction system. Visual teaching methods have greatly improved the acquisition of course information by college students, effectively mobilizing their interest in learning [11]. Ruiz discussed the principles that should be followed when designing the functionality of user interfaces and extracted design principles related to them [12]. Visual design enriches the visual effects of human-machine interfaces, and many scholars have conducted relevant analyses of the visual design of human-machine interfaces.

In response to the need for optimization of visual design for computer human-computer interaction interfaces, this study constructed a wireless network-based color ICE system for this purpose. Moreover, this study analyzed the various constraints and visual elements of human-machine interface design. Then, a visual design standard for human-machine interfaces under wireless networks was proposed, using the wireless network-based visual design color ICE algorithm to enhance the overall clarity of the interaction interface in terms of overall brightness and local contrast.

2. CONSTRAINTS AND VISUAL DESIGN ELEMENTS IN HUMAN-MACHINE INTERFACE DESIGN

2.1 Constraints for Human-Computer Interaction Interface Design

The technological platform on which the Internet operates is a key constraint in user interface design. When an interface cannot be fully displayed on the screen, users can use the scroll bar on their phone to browse the entire interface, making it inconvenient to use. Moreover, if users ignore the scroll bar, they might not see the main content of the interface, leading to usability issues. With the development of the Internet, browsers are continually being upgraded and developed. Due to the product development cycle and market competition, the functional support offered by different browsers may vary slightly. One version of the browser cannot display correctly in another browser, and the functionality of the same browser is usually incompatible in reverse. Therefore, sites supported by lower versions can usually run on higher versions, but do not work in the opposite situation. There are significant differences between different flow meters, especially in supporting complex functions. The slow display speed of web pages may cause poor usability issues for users. The most commonly-used elements of an interface are text and images, which have little impact on the website. Regular images are equivalent to multi-page text. Therefore, changing the image size is very important for website design.

The main visual elements of computer human-computer interaction interface design are: text, colors, graphics, images, symbols, points, lines, surfaces, etc., including 3D space modeling, textures, dynamic visual elements, and other elements [13]. Of the various elements comprising interface design, shape is the easiest element to understand. The form in interface design refers to the sublimation and improvement of internal elements into external appearance factors, such as quality, organization, structure, connotation, and function. Regardless of its complexity, it can be classified into four fixed structures: points, lines, surfaces, and bodies.

2.2 Visual Design Elements in Human-Machine Interface Design

2.2.1 Text Elements

Text itself is only an intuitive reproduction of visual communication methods and cannot be replaced by other elements or design methods. The reading of text not only enables one to obtain information, but also allows the user to experience the content conveyed by the text from its appearance. Its characteristics are: 1) using words as the object of description is not easy to cause ambiguity in information expression, and can convey accurate and clear information; 2) due to the relatively fast transmission speed of text information and the relatively low requirements for devices and networks, it is the most direct, accurate, and detailed way of transmitting information, and also the main conveyor of information on the Internet.

When designing human-computer interaction interfaces, text is often seen as a graphical element that can be used for regional distribution or layout adjustments [14]. Good text design can leave a deep impression on the user, not only conveying information and notifications, but also increasing the attractiveness of the interface. Enhancing the visual effect of software interaction interfaces can achieve aesthetic goals, which is an important issue that designers should consider when creating interactive software interfaces.

2.2.2 Image Elements

Images are the material representation of human visual perception, which can be obtained using optical devices such as cameras and mirrors, and can also be painted using artificial methods [15]. In human-machine interface design, images are stored digitally and through digitized pixels. Images play a very important role in human-computer interaction interfaces, as they can be used flexibly and creatively. There are two types of images: static images and dynamic images. Static images include photos, images, paintings, etc., while dynamic images include animations and videos [16–17].

Static images dominate the computer interface of human-computer interaction and are often used for buttons, screens, thumbnails, and information. When the compression speed is different and combined with image format, it does not affect image quality, so almost all systems can provide good image quality with the smallest storage space. Dynamic images refer to the continuous switching of images from multiple layers over time to achieve animated effects. Image format is small and easy to use in mobile network environments, but the dynamic effects produced are also relatively simple. Animation has more abundant expression levels, and is also a more common expression on the Internet. Also, because it combines voice and image expressions, it is widely used in visual interaction design.

2.2.3 Color Elements

Color is a natural product. Since the emergence of humans, whether in work, study, or life, people have been learning how to use color and have accumulated a wealth of knowledge about it. In the design of visual interactive interfaces, the basic theoretical research on color elements has also received great attention from designers. Color has three elements: hue, brightness, and purity. Hue refers to the different forms of color, just like a person's face, which can be identified by means of color. Brightness refers to the brightness and darkness of a color, and the strength of the color is adjusted based on the brightness and darkness. The purity of a color refers to its brightness.

During visual communication, people often use these characteristics to identify colors and understand the emotions expressed by colors. The psychological effects of color are conveyed by the physical light stimulation of color, which has a direct impact on the first visual perception of the human body. Everything has its own unique color, and each color gives people a different feeling, known as "visual touch". The dynamic effect of a human-computer interaction interface on user experience must address two main problems: the first is the manageability of dynamic information. Users must be able to freely control the information flow. Secondly, this period should not exceed the user's mental expectations. Due to the strong "visual stimulus effect" generated by dynamic information presented on the interface.

3. VISUAL DESIGN CONSIDERATIONS AND STANDARDS FOR HUMAN-MACHINE INTERFACES IN WIRELESS NETWORKS

With the continuous development of wireless networks, various mobile communication products use human-machine interface design to improve interaction quality and user satisfaction. With the increasing emphasis on quality of life, the user experience of products is also receiving increasing attention. Because of the development of interactive technology, the design of interactive human-machine interfaces has also changed, mainly manifested in the constituent elements of the interface and the design language. When designing interfaces, designers should take into account not only the user's computer interaction behaviors, but also their aesthetic values. Applying aesthetic standards to human-machine interface design can improve the appearance and appeal of the interface and improve the user's operational efficiency.

3.1 Visual Design Considerations for Computer Human-Machine Interaction Interface Based on Wireless Network Technology

Visual design of computer human-computer interaction interfaces based on wireless network technology refers to the visual design principles and techniques applied when interacting with computers using devices connected to wireless networks, such as smartphones, tablets, or other mobile devices [18]. Due to significant differences in the screen size and resolution of wireless devices, in visual design, it is necessary to consider the display effects of various terminals [19]. The adoption of a responsive design approach can automatically adjust the layout and element size of the interface based on the screen size and orientation of the device, ensuring that users can achieve the best user experience on different devices. For a wireless device, the area of the display screen is limited, so the interface should be as concise and clear as possible.

When designing interactive elements, consideration should be given to the user's manipulation of the touch screen. Large enough buttons and action areas should be used so that users can easily click or touch them. At the same time, people provide clear feedback, such as changes in button state or animation effects, to enhance user perception of operations. There is also a need to ensure that the interface design complies with accessibility principles, making it easy to use by users with different abilities and needs. For example, selecting contrast and color appropriately makes it easy for users to recognize elements on the interface. In addition, adjustable font sizes and other auxiliary functions are provided to better meet the personal needs of users. Because the connection speed of wireless networks may be limited, interface design should optimize loading time and response speed. Suitable image compression and resource optimization techniques are used to reduce the amount of data transfer and increase the loading speed. At the same time, the interaction process should be designed to be smooth and reduce unnecessary waiting time.

3.2 Visual Design Standards for Human-Machine Interface in Wireless Networks

3.2.1 Comparison Standards

For interface design, comparison can create a visual focus on the interface, making the subject stand out more prominently against the background. In interface design, size relationship is a very important factor, and the contrast between different areas can have different visual effects on users. The size relationship between areas determines the user's basic impression of the system. The smaller the size, the more favorable the user is towards the system. The difference in size can produce a clear but surprising feeling. People can make the key parts more prominent, which can better highlight the theme.

The contrast between light and dark is one of the most fundamental elements of color perception. By utilizing this contrast, the main body can be highlighted, making key menus or graphics in the interface brighter. Against a dark background, it can enhance the subject's status. Texture is also a very important image element of human-machine interface design. The most common textures are smoothness, concavity, roughness, and so on. Texture enables emotional communication with users. In the interface, different material effects can be used for comparison, and many methods can be used to produce contrast. However, it must be pointed out that the form of contrast can appear only in elements with the same attribute, and cannot appear in elements with different attributes. Moreover, the use of comparative strategies for cross mixing and combination can enhance the aesthetics of the interface.

3.2.2 Coordinated Standards

Good interface design should make the interface vivid and unique, avoid monotony, keep the interface elements harmonious, soft and friendly, and avoid a sense of complexity. Lack of harmony would make the interface stiff and cluttered, and lack of harmony would make the interface flat and dull. A harmonious whole is formed by rational arrangement. 1) Master-slave relationship is to clarify the "main" and "supporting" characters in the interface to attract users' attention. A clear master-slave relationship prevents user confusion, as overly powerful protagonists can make the interface appear tacky. 2) Dynamic and static performance is a combination of dynamic and static elements in interface design. Dynamic performance includes screen animation and object development, while static performance usually refers to buttons, text, etc. Overall, dynamic components account for a large proportion of the interface, while static components account for a small proportion.

3.2.3 Balance Standards

The balancing of screen content is very important, and the simplest way to achieve this balance is to divide the interface into three parts. The central axis of the screen is located at the bottom one-third of the plane line to maintain spatial balance. Balance is not the same as symmetry, and a symmetry approach gives the product formality, but lacks vitality. Therefore, interface design does not advocate symmetrical standards. The key point is also an aspect of balance. The human visual perception of the flow from top left to bottom right is relatively natural. Placing titles and illustrations in the bottom right corner would give a natural impression, although it causes imbalance.

In the visual design standards for human-machine interfaces in wireless network environments, the most basic design principles are those of consistency and ease-of-use. Consistency here refers to the consistency of interface design style, user interface layout, and navigation. Ease-of-use means that the navigation of the user interface should be simple and clear. In mobile devices, user interface operations are often relatively easy, so users expect to execute all actions as quickly as possible [20–21].

4. COLOR ICE ALGORITHM FOR VISUAL DESIGN OF HUMAN-COMPUTER INTERACTION INTERFACE BASED ON WIRELESS NETWORK

With the development of information technology, people's lives have undergone significant changes. As a new form of information exchange, the Internet has become the current mainstream method of communication [22–23]. In this context, wireless networks have also played an important role, and wireless network technology has had a significant impact on the visual design of human-computer interaction interfaces. In this study, the brightness component MaxRGB(n,m) of a planar visual image has been set to the maximum value for the three primary colors R, G, and B, specifically:

$$\mathrm{MaxRGB}(n,m) = \max(0\mathrm{riR}(n,m),\ 0\mathrm{riG}(n,m),\ 0\mathrm{riB}(n,m)) \tag{1}$$

The number of k grayscale values where the number of (n, m) pixel points exceed the threshold is represented by i, and the threshold k is:

$$k = \mathrm{unit8}(\log * \mathrm{width} * \frac{100}{256}) \tag{2}$$

where unit8 represents a positive 8-bit binary amount; 256 represents the number of grayscale values, and the mapped grayscale values are also exponential mapping functions, represented as:

Figure 1 Original image of the human-machine interaction interface of the drone control panel.

Figure 2 The human-machine interaction interface image of the drone control panel after color image correction and enhancement.

$$\text{TraRGB}(n, m) = 225 \times ((i - 1)/(m - 2))g \tag{3}$$

where i and g are constants.

Adjusting the overall brightness can improve the details of weakly-lit areas in the image. Secondly, it is necessary to combine the grayscale pixel values of local areas to increase the local brightness contrast of the image and make the image details clearer.

$$\text{MedRGB}(n, m) = \text{median}, \ (\text{TraRGB}(n, m)) \tag{4}$$

The local contrast of the image colors is enhanced:

$$\text{ResRGB}(n, m) = g(\text{TraRGB}(n, m) - \text{MedRGB}(n, m) + \text{TraRGB}(X, Y)) \tag{5}$$

To verify the effectiveness of color ICE, it was compared with the visual image color ICE effect of the human-machine interaction interface based on the drone control panel and the original image. This comparison is shown in Figure 1 and Figure 2.

Figures 1 and 2 show that the luminance of the original image was poor as was the clarity of the image. By means of color ICE technology, the visual brightness and clarity of human-computer interaction interfaces have been enhanced, and the saliency of interface details has also been improved. This indicates that improving color ICE technology can effectively increase the luminance and clarity of human-computer interaction interfaces.

In order to further demonstrate the effectiveness of color ICE technology, a comparison was made between the grayscale values of the visual images of the human-computer interaction interface before and after the use of color ICE technology. For comparison, the results are shown in Figure 3 and Figure 4.

As shown in Figures 3 and 4, the original grayscale values were relatively concentrated, containing blurry details, low contrast, and low contour saliency in the original image. After using color ICE technology for improvement, the distribution of grayscale values was relatively uniform. The improved image details were more prominent; the edges were clearer; and the visual performance was better than that of the original image. This also indicates that color ICE can improve the grayscale value of an image.

In order to analyze and compare the performance of color ICE technology in wireless network-based human-machine interaction interface visual design, this study conducted experiments using traditional color enhancement systems, binocular color enhancement systems, and color ICE systems. The experimental settings had three evaluation indicators: visual brightness, visual clarity, and interface detail significance of the human-machine interaction interface. The improvement effects of three systems were analyzed, and the peak improvement effect was 1. The specific effects are shown in Table 1.

The interval of visual clarity is [0,1]. According to the analysis results, the visual brightness effect was improved

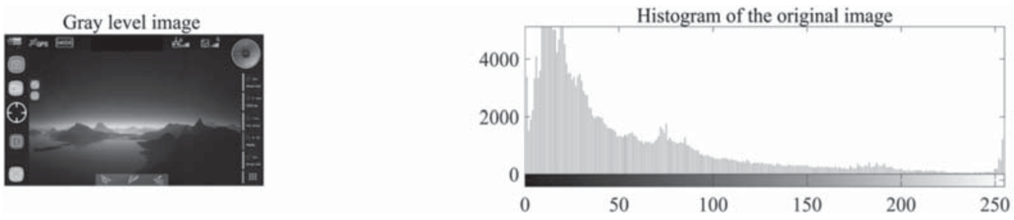


Figure 3 Histogram and grayscale values of the original drone control panel human-machine interaction interface.

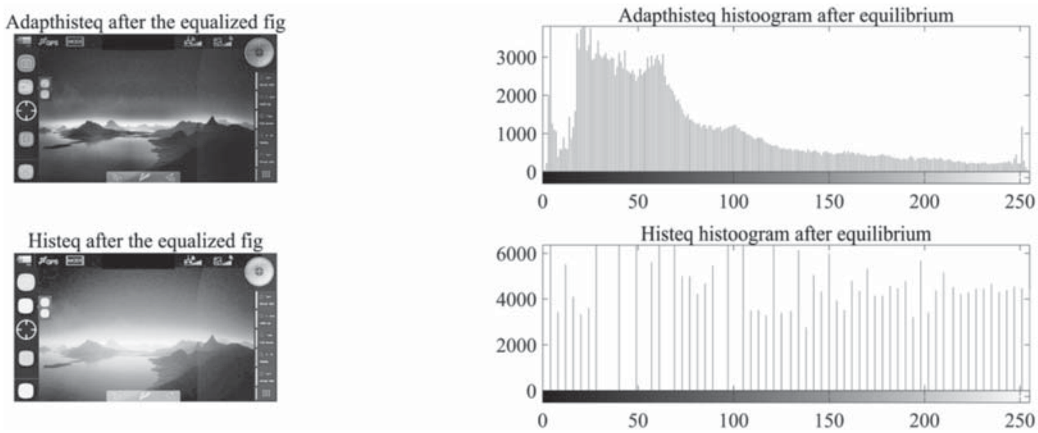


Figure 4 Histogram and grayscale values of the human-machine interaction interface of the drone control panel after color image correction and enhancement.

Table 1 Analysis of visual brightness, visual clarity, and interface detail significance effects of three systems.

	Traditional color enhancement system	Binocular color enhancement system	Image correction and enhancement system
Vision brightness	0.56	0.62	0.84
Visual clarity	0.71	0.69	0.79
Significance of interface details	0.62	0.70	0.83

to 0.56 in traditional color enhancement systems, 0.62 in binocular color enhancement systems, and 0.84 in color ICE systems. Under traditional color enhancement systems, visual clarity was improved to 0.71; under binocular color enhancement systems, visual clarity was improved to 0.69; under color ICE systems, visual clarity was improved to 0.79. Under the traditional color enhancement system, the significance of interface details was increased to 0.62; under the binocular color enhancement system, the significance of interface details was increased to 0.70; under the color ICE system, the significance of interface details was increased to 0.83. Through comparison, it was found that the color ICE system significantly improved the visual brightness, visual clarity, and details of human-computer interaction interfaces compared to traditional color enhancement systems and binocular color enhancement systems.

Further analysis was conducted to determine the performance of color ICE technology for visual design of human-machine interaction interfaces based on wireless networks. The contrast enhancement index and mean gray value of human-machine interaction interfaces under traditional color enhancement systems, binocular color enhancement systems, and color ICE systems were compared. The evaluation indicators were overall brightness and local contrast. The specific color enhancement effects are shown in Table 2.

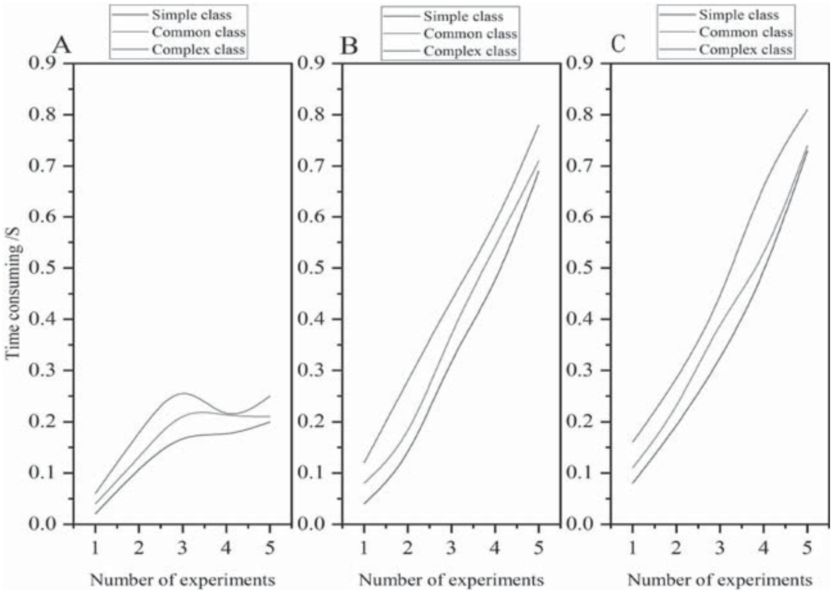
In the data presented in Table 2 shows that in terms of overall brightness, the contrast enhancement index and mean gray values of the color ICE system were 4.52 and 181.52 respectively, which were higher than those of the other two systems. Regarding local contrast, it can be seen that the contrast enhancement index and average grayscale values of the color ICE system were 4.69 and 113.36 respectively, which were also higher than those of the traditional color enhancement systems and binocular color enhancement systems.

An analysis was conducted to determine the improvement in efficiency of various color ICE systems in human-computer interaction interface visual design. Three different types of visual design enhancements, namely simple, common, and complex, were set up. Five color enhancement experiments were conducted on the interaction interface. The enhancement time required by each of the three systems is shown in Figure 5.

Figure 5A shows the time consumption analysis of the color ICE system; Figure 5B indicates the time consumption analysis of the binocular color enhancement system; and Figure 5C represents the time consumption analysis of the traditional color enhancement system. When the color ICE system was used to enhance the visual design of simple human-machine interfaces, the maximum time consumption was 0.20s, which was 0.49s less than the time required by the

Table 2 Enhancement effects of three systems.

Index	Traditional color enhancement system		Binocular color enhancement system		Image correction and enhancement system	
	Overall brightness	Local contrast	Overall brightness	Local contrast	Overall brightness	Local contrast
Contrast improvement index	1.32	1.25	3.51	3.74	4.52	4.69
Mean of gray value	115.46	100.21	143.60	101.81	181.52	113.36



(a) Time consuming analysis of color image correction and enhancement systems
(b) Time consumption analysis of binocular color enhancement system
(c) Time consumption analysis of traditional color enhancement systems

Figure 5 Time consumption analysis of three different interactive interface visual design color enhancement systems.

binocular color enhancement system, and 0.53s less than the traditional color enhancement system. When the color ICE system was used to enhance the visual design of common human-machine interfaces, the maximum time consumption was 0.23 seconds, 0.48 seconds less than for the binocular color enhancement system and 0.51 seconds less than the traditional color enhancement system. When the color ICE system was applied to enhance the visual design of complex human-machine interfaces, the maximum time consumption was 0.29 seconds, 0.49 seconds less than the binocular color enhancement system, and 0.52 seconds less than traditional color enhancement system. These results indicate that when the color ICE system is used for interactive interface visual design based on wireless networks, it outperforms the other compared systems in terms of time consumption and processing efficiency.

5. CONCLUSIONS

In summary, after analyzing the visual design standards and color elements of human-machine interfaces under wireless networks, the experimental verification of the color ICE system of the constructed human-machine interaction interface visual design showed that it can enhance the overall luminance and local contrast of the HMI interface, producing a better effect than traditional color enhancement systems. However, during the development of interactive systems, the human-computer interaction design stage still has several problems requiring solutions, such as how to maximize the design of simple and aesthetically pleasing interfaces so as to make the user's computer-interaction experience both pleasant and convenient. By means of wireless networks and technological innovations, the design of human-computer interfaces can continue to innovate, develop, and meet the needs of the market. Therefore, the optimization of human-computer interaction design not only effectively improves user satisfaction; also it also applies visual design principles to computer interface design in order to improve the user experience of the interface, make the interface clearer, and improve user efficiency.

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